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PURINE METABOLITE LEVELS IN THE LARVAL EXCRETA OF SILKWORM *BOMBYX MORI* L.

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The larval excreta of *Bombyx mori* were analysed for purine metabolites. The 1st and 2nd instar larvae excrete more guanine and adenine than any other product. Whereas hypoxanthine and xanthine are excreted in larger concentrations during 3rd instar, uric acid excretion predominates in 4th and 5th instar larvae. The excreta of 5th instar larvae contain allantoin and allantoic acid. Urea appears in the excreta throughout the larval period. Gaseous ammonia is excreted from 2nd instar onwards presumably due to a non-purine degradation.

INTRODUCTION

A number of end products of nitrogenous excretion have been assayed in the excreta of lepidopteran larvae (RAZET, 1961 ; BURSELL, 1967 ; CORRIGAN, 1970). However very little information is available with regard to the excretory products in *Bombyx mori* (BURSELL, 1967 ; CORRIGAN, 1970 ; MURRAY, 1971). *B. mori* excretes a number of amino acids (YOSHITAKA & ARUGA, 1950) and uric acid is the predominant end product (MANUTA, 1949 ; TOJO, 1970a, b, 1971) ; which has been shown to increase on a diet rich in protein (ITO & MUKAIYAMA, 1964). MANUTA (1949) has noted that allantoic acid rises from a low level just after each molt and a significant decrease occurs in allantoic acid excretion at the time of silk extrusion. In view of these findings it was considered necessary to analyze the purine metabolite levels in the larval excreta of silkworm and to note whether the uric acid forms a major catabolite.

MATERIAL AND METHODS

Fresh excretory pellets of *Bombyx mori* were dried to a constant weight at 80°C. The pellets collected from an instar larva were pooled and powdered in a mortar. About one kg of *Morus alba* leaf was also oven dried and powdered. These powders were assayed for the following.

Nitrogen and Uric Acid

Total nitrogen was determined by a Kjeldahl method (HOROWITZ, 1970). Twenty mg powder was homogenized in glass tissue grinder with 1 ml extracting medium (water, 0.1M glycine buffer pH 9.4, 0.4% lithium carbonate) and chloroform followed by centrifugation at 2500 rpm for 15 min. Uric acid in the clear supernatant was measured using the enzyme uricase (Nutritional Biochemical Corporation) according to the method of DUBBS *et al.* (1956).

Guanine, Adenine, Hypoxanthine and Xanthine bases

Twenty mg powder was extracted with 1 ml methanol–pyridine-water (5:4: 1) and filtered through sintered glass funnel (MPW extract). 10μl filtrate was cospotted on Whatman No. 1 chromatography paper with 5μg of known base (obtained from Sigma Chemicals) and run for 20 to 24 hr in isopropanol-HCl-water (170 : 41 :39) as according to WYATT (1951). Bases were located under u v light and 2 cm^2 were cut out and eluted into 3 ml 5% percholoric acid. The absorption of base at 260 nm was measured and compared with that of the standard using a Beckman DU$_2$ u v spectrophotometer.

Allantoin, Allantoic Acid and Urea

15μl of above extract was spotted on 0.25 mm thin-layer cellulose plates (21 x 21 cm) and run in

two dimensions, first with *N*-butanol–pyridine-water (6 : 4 : 3) and second with 70%*N* -propanol. The carbamylamines were identified on the chromatograms with modified EHRILICH's spray reagent (2 g *p*–dimethylamino–cinnamaldehyde in 100 ml 6N HCl and 100 ml 95% ethanol). The coloured spots were scraped into 3 ml 95% ethanol and eluted. The intensity of eluate was compared at 420—430 nm with that of a known standard using a photoelectric colorimeter. The OD obtained for the extract was compared with that of a standard solution analyzed in the same manner (LEVINE *et al.*, 1961).

Glyoxalic Acid

Glyoxalic acid was detected in the extracts by paper chromatography (LEWIS & WEINHOUSE, 1957). MPW extract was spotted on filter paper and irrigated overnight in a solvent mixture consisting of 3 : 2 : 1 · 5 butanol-pyridine-water. After drying, the paper was sprayed with 0.2% *o*-phenylenediamine in ethyl alcohol containing 1% nitric-acid. On heating to 70°C for 20 minutes, glyoxalic acid appeared as a characteristic yellow spot. Glyoxalic acid concentrations in the extracts were determined according to KRAMER *et al.* (1959).

0.5 ml MPW extract was incubated with 1.0 ml 1% phenylhydrazine at 110°C for 5 minutes. After cooling at room temperature 1. 0 ml conc. HCl was added followed by 0.5 ml 1% potassium ferricyanide solution. The colour density was read after 2 minutes at 520 nm against a reagent blank containing extraction medium and compared with that of a known standard solution empolying a photoelectric colorimeter.

Ammonium salts

0.5 g powder was homogenized in 10 ml 0.1N HCl and filtered through Whatman No. 1 filter paper. The ammonia in 5 ml of this filtrate was expelled by the addition of 5 ml 40% KOH and collected through steam distillation in a micro-Kjeldahl apparatus. It was later estimated colorimetrically by nesslerization (OSER, 1965, page 1218).

Gaseous Ammonia

50 larvae were allowed to feed on sliced mulberry leaves in a 1 liter conical flask, fitted with a two-holed rubber stopper. The set up used for collecting the NH_3 released through respiratory gases was similar to that of collecting ammonia according to VAN SLYKE & CULLEN (HAWK *et al.*, 1951).

RESULTS AND DISCUSSION

Table 1 incorporates the results of the qualitative and quantitative analysis of purine excretion in the larval development of *B. mori*. The principal excretory products differ with reference to instars. The first and second instar larvae excrete more guanine and adenine than any other purine metabolic intermediate, whereas hypoxanthine and xanthine are excreted in larger concentrations during the 3rd instar. Uric acid is excreted more than any other products of purine degradation in the 4th and 5th instars. Allantoin and allantoic acid excretion is noted only in the 5th instar.

The total excretory nitrogen decreases gradually upto 4th instar (Table 2). Urea is excreted throughout the larval period but its concentration in the feces is more during the 4th instar. Gaseous ammonia is excreted from the 2nd instar onwards, which is more in 3rd instar. Glyoxalic acid is not detected in the feces at any stage of larval development (Table 1).

Obviously the results support the findings of RAZET (1953, 1956, 1961, 1966) who obtained evidence that some terrestrial insects excrete primarily uric acid and allantoin and allantoic acid. Presumably the action of allantoicase on allantoic acid may yield the urea and glyoxalate in later instars.

In non-insect development, due to suppression of specific enzymic activities the purine degradation will either be partial or arrested at later stages of development and consequently such intermediates will not be found in the excreta (MURRAY, 1971 ; HARTENSTEIN, 1970). The gradual shift in the degradatory pattern from guanine to allantoic acid noticed during the larval development of *Bombyx mori* is therefore interesting. The later instars of the silkworm

TABLE 1. Changes in the levels of intermediates of purine degradation in the excreta of *Bombyx mori* during larval development

Intermediate	μmoles/g dry excretory matter						
	I Instar	II Instar	III Instar	IV Instar	V Instar	pupal exudate	Leaf
Guanine	2.417 ±0.09	2.39 ±0.05	1.119 ±0.07	0.05 ±0.006	0.019 ±0.005	0	0
Adenine	2.14 ±0.06	2.83 ±0.10	1.98 ±0.05	0.02 ±0.001	0.01 ±0.0016	0.01 ±0.0012	0.01 ±0.001
Hypoxanthine	0.58 ±0.03	0.50 ±0.051	1.73 ±0.001	0.03 ±0.001	0.08 ±0.02	0.01 ±0.001	0.02 ±0.0018
Xanthine	0.41 ±0.049	0.02 ±0.001	2.51 ±0.08	0.31 ±0.01	1.6 ±0.11	2.56 ±0.11	0.01 ±0.001
Uric acid	0.07 ±0.01	0.01 ±0.005	1.67 ±0.05	2.78 ±0.11	5.21 ±0.14	4.08 ±0.23	0
Allantoin	0	0	0	0	0.56 ±0.01	1.37 ±0.06	0
Allantoic acid	0	0	0	0	0.07 ±0.03	1.41 ±0.09	0
Glyoxalic acid	0	0	0	0	0	0.21 ±0.04	0

Values are $\bar{X}$ ± S D of six observations.

TABLE 2. Changes in urea and gaseous ammonia excretion in *Bombyx mori* during larval development

Product	μmoles/g dry excretory matter						
	I Instar	II Instar	III Instar	IV Instar	V Instar	pupal exudate	Leaf
Urea	0.26 ±0.10	2.8 ±0.33	4.6 ±0.31	4.81 ±0.16	3.303 ±0.12	0.05 ±0.01	0
Ammonium salts	0.58 ±0.12	1.16 ±0.8	2.25 ±0.7	5.16 ±1.52	2.56 ±0.71	0	0
[1]Gaseous NH_3	0	12.7 ±1.2	174 ±5	57.7 ±3.9	49.1 ±2.9	0	0
Total Nitrogen	0.15 ±0.08	0.14 ±0.06	0.12 ±0.07	0.09 ±0.04	0.13 ±0.05	0.06 ±0.02	0.18 ±0.01

Values are $\bar{X}$ ± SD of six observations.

[1] μmoles of NH_3 excreted/individual/hr.

are probably characterized by the presence of necessary enzyme set up to degrade the purine metabolites further.

A gradual increase in uric acid fraction upto 5th instar and then a steady decline in the pupal exudate could not be explained by the accumulation of allantoin, allantoic acid, urea or uric acid. Similar increase in uric acid excretion was reported at successive instars of *Neodiprion sertifer* (FOGAL & KWAIN, 1974). As the development proceeds the purine degrading enzymes get differentiated and the degradation pathway may be completed. In pupae probably due to differentiation of allantoicase glyoxalic acid and urea result as degradable products.

Excretion of gaseous ammonia in larval stages increases upto 3rd instar and later on gradually decreases. Terrestrial isopods excrete gaseous ammonia (HARTENSTEIN, 1970 ; WIESER & SCHWEISER, 1970). The venue of exclusion of ammonia gas in silkworm is not clear. If it is excluded through feces, obviously it would be due to autolytic degradation of the intestinal microflora. As it is collected in feeding stage it does not seem to have fecal origin.

BHEEMESWAR (1959) reported that ammonia may arise in part by direct deamination of amino acids. Amino acid oxidases have been demonstrated in the fat body of many insects (AUCLAIR, 1959). The activity of later enzymes and also that of glutamic dehydrogenase in the presence of transaminase may yield gaseous ammonia (MCALLAN & CHEFURKA, 1961; EMMERICH *et al.*, 1965) which escapes through tracheal system. So the excretion of gaseous ammonia in the silkworm could be due to a non-purine breakdown.

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CONSUMPTION, DIGESTION AND UTILIZATION OF FOOD BY LARVAE OF *SPODOPTERA LITURA* F. (NOCTUIDAE : LEPIDOPTERA)

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Indices of consumption, growth, digestibility and efficiency of conversion of ingested and digested food materials in fifth and sixth instar caterpillars of *Spodoptera litura* with five food plants are calculated. Reasons for the disparity observed among the values are discussed. Utilization of total nitrogen from the food plants by the caterpillars is also determined.

INTRODUCTION

Insects feed upon diverse types of organic substances. Each insect species is adapted to a specialised food which it can utilize most efficiently. The qualitative nutritional requirements of growing insects may appear relatively uniform and adaptive nutritional differences have to be sought at quantitative level. Hence a clear picture of comparative nutrition of insects will not emerge until quantitative studies are emphasized. Studies on the consumption, digestion and utilization of food plants by insects are important both from fundamental and applied points of view. They provide information on the quantitative loss brought about by the pests. Consumption indices can also be taken as indirect measurements of the relative susceptibilities of different varieties of crops to pest infestation. Studies on Indian insects along the lines mentioned above are few and include those of SHYAMALA *et al.* (1956), SHARADA & BHAT (1957) and SHYAMALA *et al.* (1960).

The present studies were undertaken to find out the indices relating to the consumption, digestion and utilization of five economically important host plants by the larvae of *Spodoptera litura,* a polyphagous pest of crops.

MATERIALS AND METHODS

Fifth and sixth instar caterpillars of *S litura* taken from laboratory cultures were used. The food consumed (see Table for different host plants used), excreta produced and the weight gained by the caterpillars over the entire experimental period were determined both on dry weight and fresh weight basis.

Dry weight of larvae was estimated using the mean percentage of dry matter of an aliquot of similar larvae. To find out the dry weight of the larvae they were killed by freezing and then dried at 80°C to a constant weight. The mean weight of the insects was calculated by summing up the initial and final weights determined every dry and dividing by the number of weighings. The estimation of total nitrogen in the leaves, caterpillars and faecal pellets was done by the micro-Kjeldahl method.

All the indices relating to the consumption, digestion and utilisation of food plants were culculated according to WALDBAUER (1968).

RESULTS AND DISCUSSION

Consumption of food

The data on the average daily consumption of leaves on a wet weight basis are presented in Table 1. The total food intake per larva varied greatly. There was no feeding activity on the fifth day in the caterpillars fed on banana, castor and bhindi as they started pupating on that

TABLE 1. Average wet weight of food ingested per larva of *S. litura* on different days (gm)

Food plant	1st day	2nd day	3rd day	4th day	5th day	Total consumption
Banana	0.150	0.148	0.390	0.374	..	1.062
Castor	0.114	0.164	0.252	0.334	..	0.864
Tomato	0.120	0.101	0.276	0.257	0.346	1.100
Bhindi	0.103	0.138	0.171	0.236	..	0.648
Sweet potato	0.157	0.124	0.180	0.360	0.378	1.199

day. The food intake was maximum with sweet potato followed by tomato. A rise in food consumption by the caterpillars was observed from the third day onwards with all the host plants.

The different consumption indices (CIs) of the larva are presented in Table 2. The fresh weight consumption index as presented in column 3 of the Table is generally taken as a measure of the behavioural response of insects towards the food WALDBAUER, 1968). The data presented show that there is in general a direct correlation between the succulence of host plants (as indicated from the dry wright percentage in column 1) and the feeding rate of insects, the more succulent banana and sweet potato being consumed more than the less succulent tomato, bhindi and castor.

TABLE 2. Various consumption indics (CIs) of the larvae of *S. litura on* different food plants

Food plant	Percentage of dry matter in leaves	Fresh weight of food: fresh weight of larva	Dry weight of food: fresh weight of larva	Dry weight of food: dry weight of larva
Banana	15	2.10	0 33	3.20
Castor	28	1 00	0 29	2.83
Tomato	20	1 17	0 25	2.33
Bhindi	24	0.68	0.24	2.37
Sweet potato	16	2.45	0.39	3.88

The dry weight : fresh weight consumption index as presented in column 4 of Table 2 is of nutritional interest since this index measures the rate at which nutrients enter the digestive system (WALDBAUER, 1968). The highest and the lowest CIs were recorded with sweet potato and bhindi respectively, the other food plants occupying intermediate positions.

SOO HOO & FRAENKEL (1966) and WALDBAUER (1964) found that the dry weight CIs were always higher than the corresponding fresh weight CIs because the insects contained a lower percentage of dry matter than their food. The present observations also corroborate the above finding.

Growth rate on different food plants

The relative growth rates of the larvae calculated for the different food plants are presented in Table 3. The maximum growth rate was for the larvae fed on castor leaves and the minimum growth rate for those fed on sweet potato leaves. Bhindi, tomato and banana occupied intermediate positions with respect to the growth of the larvae.

Digestibility of different food plants

Approximate digestibility (AD) taken as the index of digestibility in the present studies are presented in Table 3. Many authorities including WALDBAUER (1964) have

referred to this measure as the coefficient of digestibility. However this is misleading since the difference between the weight of the ingested food and the weight of the faeces does not represent the amount actually digested. On the dry-weight basis approximate digestibility was the highest with bhindi and the lowest with tomato. The maximum digestibility on fresh weight basis was with castor leaves and the minimum with banana leaves.

TABLE 3. Growth rate of larvae of *S. litura* on different food plants and their approximate digestibility

Food plant	Growth rate	Approximate digestibility	
		Dry weight basis	Wet weight basis
Banana	0.38	48.68	47.30
Castor	0.54	67.11	76.80
Tomato	0.41	48.16	57.00
Bhindi	0.42	72.55	72.10
Sweet potato	0.33	51.01	58.00

Utilization of food

Efficiency of conversion of ingested food to body substances (ECI) or gross efficiency: The indices of gross efficiency of utilization of food plants, both on dry weight and wet weight basis, are given in Table 4. The values differed for different host plants. On dry matter basis, the values ranged between 8.70 and 19.35 per cent. The maximum gross efficiencies on wet and dry weight basis were 53.50 and 19.35 per cent respectively and both were with castor. The minimum gross efficiency was observed with sweet potato on both dry and fresh weight basis.

Efficiency with which digested food is converted to body matter (ECD) or the net efficiency: The values on the net efficiency with different host plants by the larvae of *S. litura* are also given in Table 4.

TABLE 4. Utilization of food plants by the larvae of *S. litura*

Food plant	ECI (%)		ECD (%)	
	Dry weight basis	Wet weight basis	Dry weight basis	Wet weight basis
Banana	11.90	18.03	25.41	38.90
Castor	19.35	53.30	26.10	68.10
Tomato	17.23	35.00	35.98	61.10
Bhindi	18.54	48.00	24.94	67.40
Sweet potato	8.70	13.66	16.76	23.31

ECI Efficiency of conversion of ingested food to body substances.

ECD Efficiency with which digested food is converted to body matter

There is difference on he net efficiency among the different host plants and the values range from 16.76 to 35.98 per cent on dry matter basis and between 23.31 to 68.10 per cent on fresh weight basis. The maximum ECD on dry matter basis is found to be with tomato while on fresh weight basis, it is with castor. The minimum ECD both on dry and wet weight basis, is with sweet potato.

Utilization of total nitrogen

Nitrogen was chosen as the constituent for an objective study because of the component's direct relationship with protein, one of the major nutrients. Measurements of the utilization of nitrogen by insects are complicated by the presence of urine in their faeces. In the present studies, determination of urine nitrogen was not attempted. But still the uncorrected coefficient of apparent digestibility (CAD) and ECI (N) should be proportionate to the corresponding corrected values, since ingested nitrogen less faecal and urine nitrogen should be the same as the amount of nitrogen retained in the body.

Coefficient values of apparent digestibility with respect to the total nitrogen [CAD (N)], indices concerning gross efficiency of utilization of nitrogen [ECI (N)] and net efficiency of utilization of nitrogen [ECD (N)] are presented in Table 5. The maximum coefficient of apparent digestibility was found to be for castor leaf (69.60) and the minimum for sweet potato (46.66). The corresponding values of ECI (N) were 76.0 per cent with banana leaves and 17.5 per cent with sweet potato respectively.

TABLE 5. Utilization of total nitrogen by the larvae of *S. litura*

Food plant	CAD (N)	ECI (N)	ECD (N)
Banana	59.10	76.00	127.00
Castor	69.60	50.00	70.00
Tomato	55.02	41.30	76.00
Bhindi	63.87	45.80	71.00
Sweet potato	46.66	17.50	40.00

CAD (N) Coefficient of apparent digestibility with respect to total nitrogeon.

The last column of the table shows that the values of ECD (N) deviated considerably from the expected 100 per cent. Previous workers (KASTING & MCGINNIS, 1959; BALOGH & GERE, 1953) also reported similar deviated values. It can be reasonably presumed that these variations are due to incomplete recovery of nitrogen during chemical analysis. The uncorrected ECD (N) thus serves as a measure of the accuracy of nitrogen determination.

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STUDIES ON THE REPRODUCTION IN *EARIAS FABIA* STOLL (LEPIDOPTERA: NOCTUIDAE): OVIPOSITION IN RELATION TO ADULT NUTRITION, MATING AND SOME ENVIRONMENTAL FACTORS

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Egg laying by mated females of *Earias fabia* reaches its maximum when adult insects are daily fed 15% solution of raffinose. However, ingestion of this trisaccharide at a concentration below the level of 1% severely reduces their egg yield. The reproductive behaviour of these pests reveals a definite circadian rhythm in which the peak of oviposition always occurs between 14.00 and 22.00 hours. Virgin females deposit extremely few non-viable eggs 'reluctantly' just before their death. But mating coupled with continuous presence of the copulated male partner significantly enhances egg output. The time of mating is related to the number and viability of eggs deposited by these moths. The implications of these findings are discussed.

INTRODUCTION

During the last one and a half decades significant information concerning investigations into various aspects of the reproduction in *Earias fabia* STOLL, a major pest of cotton and okra in the tropics (WYNIGER, 1962; LALL, 1964; SOHI, 1964), has been published intermittently by different workers (KHAN & RAO, 1969; SOHI, 1964; MEHTA & SAXENA, 1970; VISHWAPREMI & KRISHNA, 1974b, 1975). The account given in the latest report (VISHWAPREMI & KRISHNA, 1975) on the reporduction of this insect brings to light the need for a carbohydrate diet, especially raffinose, by these pests during their adult lives for achieving maximum fecundity, and impairment in oviposition in these moths when they emerge from group-reared larvae and pupae. However, our knowledge relating to the effect of nutritional and environmental factors on the reproductive potential of this pest is surprisingly meagre. In an attempt to throw more light on this aspect investigations were undertaken along this line and this communication includes results of our work on the influence of (i) concentration of raffinose solution serving as adult diet, (ii) the diel rhythm of photoperiod, (iii) mating and (iv) presence of male with female throughout her post-mated reproductive life till death, on the oviposition of the insect.

MATERIALS AND METHODS

Fattened adults of either sex (VISHWAPREMI & KRISHNA, 1974b) reared on developing seeds of okra or on epicarp of the fruit (VISWAPREMI & KRISHNA, 1974a) were used in the present study.

For determining the effect of strength of raffinose solution provided as adult food on the reproductive capacity of these insects, six concentrations (15, 5, 1, 0.5, 0.25, 0.1%) of raffinose was fed in amounts as reported earlier (VISHWAPREMI & KRISHNA, 1975) to the seed reared moths and the number of eggs deposited by them each day throughout their lives after mating was recorded.

To ascertain the influence of the diel rhythm of photoperiod on the mated female's ovipositional programme, seed- as well as epicarp-reared moths were employed in the various tests performed.

Moths emerging from seed-reared larvae and pupae were fed on a 15% solution of raffinose or glucose solution or distilled water (VISHWAPREMI & KRISHNA, 1975). But the daily food of those raised on epicarp diet consisted only of raffinose solution of similar concentration. All egg laying trials began by pairing for mating a freshly emerged female of one regimen with a newborn male of the same regimen at 6.00 hours of the 24 hour period. Oviposition of the mated moths was monitored daily till the death of the females so as to determine their egg yield during 6.00 through 14.00 (first octet) 14.00 through 22.00 (second octet) and 22.00 through 6.00 hours (third octet).

Influence of mating and of the presence of the male on oviposition was studied by comparing the total egg deposition data obtained from male-associated, seed-reared mated females with the data from the corresponding virgins as well as with the data from females which were deprived of their copulated males immediately after mating. Mating time and viability of the eggs laid by the females of the last category were also studied. The individuals used in these tests were all fed on 15% sucrose solution during their adult lives.

The general layout of all oviposition tests, outlined above, was similar to that described earlier (VISHWAPREMI & KRISHNA, 1974b). The experiments were replicated and the data statistically analysed (PATERSON, 1939).

RESULTS AND DISCUSSION

Table 1 summarises the results concerning the effect of different concentrations of raffinose fed by the adult mated females of *E. fabia* on the oviposition of these insects. Egg output was higher when the moths ingested 1, 5 or 15% solution of raffinose instead of more dilute solutions ($P<0.01$). No statistically significant difference in the total egg yield was observed amongst the females feeding on raffinose solutions at concentriations 1, 5 or 15% ($P > 0.05$) or amongst those moths imbibing this sugar at concentrations 0.1, 0.25 or 0.5% ($P > 0.05$). The maximum yield was obtained at 15% concentration.

TABLE 1. Number of eggs laid by fattened mated females of *E. fabia* fed on different concentrations of raffinose solutions during their adult lives (data pooled from five females).

Concentration	Mean number of eggs laid
15.00	604.6 a
5.00	569.6 a
1.00	534.6 a
0.50	316.2 b
0.25	293.2 b
0.10	254.8 b
Mean	428.8
LSD (1%)	147.7

Any two means followed by the same superscript letter do not differ significantly at the 1% level by the Least Significant Difference (LSD) test.

It was of interest to compare the total egg output when raffinose was provided as adult food for females whose immature stages were reared on epicarp diet and hence undernourished (VISHWAPREMI & KRISHNA, 1974a), with that of females fed on glucose provided as adult food which showed the poorest nutritional competence to stimulate egg laying (VISHWAPREMI & KRISHNA, 1975) and whose immature stages were raised

TABLE 2. Number of eggs laid by fattened mated females of *E. fabia* raised on epicarp or developing seeds of okra fruit during pre-imaginal stages and adults given raffinose or glucose solution respectively (data pooled from five females).

Experimental condition	Mean number of eggs laid (± SE)
Epicarp-reared and raffinose given in adult stage	427.2 ± 18.66a
Seed-reared and glucose given in adult stage	322.0 ± 20.50

a—Significantly different at 1% level from the value just below in the column ('t' test)
SE—Standard Error.

on developing okra seeds which served as the best larval food (VISHWAPREMI & KRISHNA 1974a). The results (Table 2) show that eggs deposited by moths fed on raffinose solution in adult stage but reared on epicarp diet was significantly greater ($P < 0.01$) than those laid by seed-reared and glucose-ingested females. The importance of raffinose as an efficiently compensating nutritional factor in the diet of adult females of *E. fabia* for their reproduction is implicit in these findings. Presumably the joint physiological influence of fructose, glucose and galactose—the three monosaccharide components of raffinose obtained by this insect during its complete utilisation of the trisaccharide (VISHWAPREMI & KRISHNA, 1975) explains the maximal egg output by moths fed on raffinose.

Data on the egg deposition by these moths affected by the diel rhythm of photoperiod are indicated in Table 3. Without exception all the mated females laid eggs between 14·00 and 6.00 hours constituting two separate octets of the 24 hour ovipositional cycle commencing from 6.00 hours every day. However, between these two octets, the second one (14.00 through 22.00 hours) always facilitated the moths to deposit significantly more eggs than the third octet (22.00 through 6.00 hours) ($P < 0.01$ or 0.05). These results clearly imply that the most favourable period for egg laying in *E. fabia* is from afternoon through early night hours in its daily cyclical ovipositional activity—an observation which supports the previous findings (see review by LALL, 1964) and which appears to be unaffected by changes in the nutritional status of the moth in its immature or adult stage. Nevertheless, alterations in the dietary conditions of this insect during its larval or imaginal life had a striking impact on egg deposition by the mated females. This means that the nutritional status of these mated females during their pre-imaginal and imaginal lives is significant as far as egg output in these insects is concerned.

TABLE 3. Number of eggs laid during second and third octets of a 24 hour ovipositional cycle by fattened mated females of *E. fabia* held on different regimens (data pooled from five females).

Regimen	Mean number of eggs laid (±SE)	
	Second octet (14.00—22.00 hours)	Third octet (22.00—6.00 hours)
Larvae and pupae reared on epicarp diet and adults fed on 15% raffinose solution	235.0 ±12.10a	190.2 ±10.49
Larvae and pupae reared on developing seeds of okra and adults fed on 15% raffinose solution	296.4 ±10.93a	211.4 ±24.28
Larvae and pupae reared on developing seeds of okra and adults fed on 15% glucose solution	184.6 ±7.10a	134.8 ±13.20
Larvae and pupae reared on developing seeds of okra and adults fed on distilled water	131.6 ±3.61aa	82.0 ±3.83

aa—Significantly different at 1% level and a at the 5% level from the value given on the same row in the next column ('t' test).

SE—Standard Error.

Information on egg laying by mated females of *E. fabia* detailed above, has been obtained when these females during their entire reproductive lives were kept in continuous association with their copulated

male partners. It is quite likely that the presence of males in the life of a post-mated female affects the number of eggs deposited by the latter. This hypothesis was also checked in the present investigation. The observations given in Table 4 show a marked increase in the egg yield obtained from mated females when they remained in constant association with their male partners in comparison to that estimated from mated moths dissociated from males subsequent to their copulation ($P<0.01$).

TABLE 4. Number of eggs laid by the fattened mated females of *E. fabia* associated with or dissociated from their copulated male partners during their life time subsequent to mating (data pooled from five females).

Experimental condition	Mean number of eggs laid (± SE)
Male present with female throughout the latter's life following mating	445.4 ± 22.81a
Male separated from female forever after mating	250.4 ± 17.16

a—Significantly different at 1% level from the value just below in the column ('t' test)

SE—Standard Error.

The oviposition experiments involving virgin females of *E. fabia* showed conspicuously low egg output (maximum 6 eggs) by these moths just before their death. A postmortem examination of their ovaries however revealed a large number of mature, unlaid eggs which was significantly higher ($P< 0.01$) (Table 5) than that recorded in the gonads of mated females after death.

TABLE 5. Total number of mature, unlaid eggs present in the ovaries at death of unmated, virgin and fattened mated females of *E. fabia* (data pooled from five females).

Experimental condition	Mean number of mature, unlaid eggs inside ovaries (± SE)
Unmated	55.2 ± 2.05a
Mated	17.0 ± 10.50

a—Significantly different at 1% level from the value just below in the column ('t' test).

SE—Standard Error.

It is evident from these findings that withholding males from the females, either from the time of the latter's emergence or subsequent to their mating, variably influences the reproductive programming of the moths. The first situation results in the inevitable existence of the females as virgins. Their preoviposition period becomes greatly extended in comparison to that reported in fattened mated females (VISHWAPREMI & KRISHNA, 1974b) and thus, in this feature, they resemble the virgins of *Plutella maculipennis* (HILLYER & THORSTEINSON, 1971). Further these unmated females, like those of many shortlived lepidopteran species including several noctuids (KLATT, 1913; RAU & RAU, 1914; SCHULZE, 1926; EIDMANN, 1931; MOKIA, 1941; BONNEMAISON 1961), retain most of their eggs until shortly before death and eventually 'reluctantly' lay some of them (ENGELMANN, 1970). In the second situation, the preoviposition period remains undisturbed but the drastic cut in the total egg output suggests that mating and the continuous presence of the male are two essential factors which function as ovipositional promoters in the reproductive life of the spotted bollworm.

TABLE 6. Number and viability of eggs laid by fattened mated females of *E. fabia* from two different regimens (data pooled from five females).

Regimen	Mean number of total eggs laid (±SE)	Mean number of fertile eggs laid (±SE)
Females mated between 5.30 hours and 7.30 hours	359.0 ±63.86a	202 ±36.98a
Females mated between 2.30 hours and 5.30 hours	92.6 ±36.08	10 ±7.87

a—*Significantly different at 1% level from the value just below in the column ('t' test)*

SE—Standard Error.

Studies on the relationship between mating period of these moths and their total egg output and viability of these eggs yielded some interesting data. As mentioned by SOHI (1964) individuals of *E. fabia* mated 2-3 days after emergence. But the time of their copulation ranged from 2.30 hours through 7.30 hours some females mating between 2.30 hours and 5.30 hours while others remaining in sexual union with males between 5.30 hours and 7.30 hours. The duration of coitus in these insects was, however, less than that reported by SOHI (1964) and varied between 45 and 90 minutes. Interestingly, females which mated during the last two hours of thier copulation period laid significantly more total and fertile eggs than those in which mating occurred earlier ($P < 0.01$) (Table 6). It is difficult at this stage to give an explanation for this phenomenon, though the time of mating in *E. fabia* appears to be a critical factor affecting there productive potential of these insects.

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ENDOCRINE CONTROL OF VITELLOGENESIS IN THE RED COTTON BUG, *DYSDERCUS CINGULATUS* FABR. (HETEROPTERA, PYRRHOCORIDAE)

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The neuroendocrine system of the adult red cotton bug *Dysdercus cingulatus* consists of the neurosecretory A, B and C cells of the pars intercerebralis, the corpus cardiacum with the chromophobe and the chromophil cells, and the corpus allatum, the anterior portion of the aorta serving as the neurohaemal organ. The corpus cardiacum or the corpus allatum does not contain any neurosecretory material from the brain.

Extripation and reimplantation techniques have revealed that both the pars intercerebralis neurosecretory cells and the corpus allatum in the normal animal are essential for vitellogenesis. However, only the corpus allatum plays a direct gonadotrophic role in the female. The neurosecretory cells serve to activate the corpus allatum.

INTRODUCTION

Regulation of vitellogenesis in insects is brought about by endocrine mechanisms which are apparently quite different in different species. The significance of the role played by the individual endocrines greatly vary in this group of animals, and the mechanisms have been reviewed recently by ENGELMANN (1970), DE WILDE & DELOOF (1973) and by DOANE (1973). In most insects vitellogenesis is stimulated either by corpus allatum as in the butterflies (HERMAN, 1975 ; HERMAN & BENNETT, 1975), in the Colorado potato beetle (DE LOOF & DE WILDE, 1970), and in the blow fly (MJENI & MORRISON, 1976), or it is stimulated apparently by the neurosecretory cells as in *Drosophila* (BOULETREAU- MERLE, 1976), *Melanoplus sanguinipes* (ELLIOTT & GILLOTT, 1976 ; GILLOTT & ELLIOTT, 1976). It may be stimulated by both as in *Locusta migratoria* though the neurosecretory cells may be playing only an indirect role (MC CAFFERY, 1976). Ecdysone appears to stimulate vitellogenesis in mosquitoes (SPIELMAN *et al.*, 1971; FALLON *et at.*, 1974) whereas juvenile hormone analogues do not (SPIELMAN *et al.*, 1971). Ecdysone on the other hand inhibits vitellogenesis in many insects (see JALAJA *et al.*, 1976). In Hemiptera, the classical work on *Rhodnius prolixus* shows that the corpus allatum is essential for vitellogenesis (WIGGLESWORTH, 1936). However, it is now established that vitellogenesis can take place in this animal even in the absence of corpus allatum, though the number of eggs developed are fewer (DAVEY, 1967) and vitellogenesis begins later and proceeds more slowly in them (PRATT & DAVEY, 1972). In *Oncopeltus* active cropus allatum is necessary for vitellogenesis whereas extirpation of median neurosecretory cells does not prevent vetillogenesis (JOHANSSON, 1958). As a detailed picture of the endocrine mechanism controlling vitellogenesis in Heteroptera is wanting except perhaps in *Rhodnius*, which is a blood sucking insect, we made an attempt to study the endocrine mechanism involved in vitellogenesis in a plant bug, *Dysdercus cingulatus*

and the present paper deals with the results obtained in this study.

MATERIALS AND METHODS

Insects used for the present study were from a colony maintained in the laboratory on soaked cotton seeds. Newly moulted adults were separated and labelled 0-day old. Thus animals of required age were available for the study.

Surgical techniques employed have already been described (JALAJA, 1974; JALAJA & PRABHU, 1976 b; JALAJA *et al.*, 1973).

Adult females 0—3 hours after emergence were used for extirpation of median neurosecretory cells (MNC). Extripation of MNC was performed on a batch of 100 females. This batch was divided into three groups: group I consisting of 60 females and groups II and III consisting of 20 females each. Animals belonging to group I were sacrificed two, four and six days after the operation. Sham operated animals were kept as controls. Into group II, MNC were implanted and into group III, corpora allata (CA) were implanted. Implantation of MNC was performed 48 hrs after extirpation. MNC clusters from female donors three days after adult emergence were dissected out and introduced into the abdomen of the host through a slit. For implantation of CA also glands from three-days-old females were used. Two CA were implanted into the operated region just after the extripation. Host from which MNC were extrirpated and into which fat bodies were implanted served as control. Allatectomy was performed on a batch of 80 females, 24—30 hrs after adult emergence. Sham operated animals were kept as controls. Allatectomised females were divided into three groups: group I consisting of 40 females and groups II and III consisting of 20 females each. Animals belonging to group I were sacrificed three, five and seven days after the operation. Animals belonging to group II served as hosts for transplantation of CA. Two active CA from three day old females were transplanted into each of these, 48 hrs after allatectomy. The CA were introduced into the abdomen through a slit. For implantation of MNC allatectomised hosts of group III were used. Forty-eight hrs after allatectomy two active MNC clusters from three days old females were dissected out and implanted into the abdomen of the allatectomised hosts. In both cases hosts into which fat bodies were implanted served as controls.

Allatectomy was also performed on insects 36, 48 and 72 hrs after emergence and median neurosecretory cells were extripated 10,20, 30 and 48 hrs after emergence, in order to find out the critical period when these operations ceased to be effective. Animals of the same age group were kept as controls after suitable operations as described above.

Some normal males were kept along with these experimental animals in glass chimneys, the top of which was covered with cloth and were fed on soaked cotton seeds. Survival rate was about 50%. Complete removal of the CA and MNC was confirmed by subsequent examination at autopsy and by staining procedures. The data from those animals in which extirpation was incomplete were discarded.

Neuroendocrine complex and ovaries were dissected out in insect Ringer (EPHRUSSI & BEADLE, 1936). Ovaries were processed for histology and histochemistry as already reported (JALAJA & PRABHU, 1976 a). Cephalic endocrine complex was fixed in BOUIN'S fluid or formol saline and was either stained whole using paraldehyde fuchsin (CAMERON & STEELE, 1959), resorcin fuchsin (Ittycheriah & MARKS, 1971) or by performic acid victoria blue method (DOGRA & TANDAN, 1964) or sections were stained by GOMORI'S method for neurosecretion. Sections were also stained in iron haematoxylin eosin for histological study of the CA.

Total length of the ovarioles and the length and breadth of the basal oocytes were measured on unfixed ovaries using a calibrated eye-piece micrometer. Camera lucida drawings of outlines of CA from serial sections were made on graph paper and a stage micrometer projected beside the outlines helped in the calculation of the area and volume of the CA.

OBSERVATIONS

I. The endocrine system of the adult

The endocrine system of the adult *Dysdercus cingulatus* (Figs. 1–5) consists of the median neurosecretory cells (MNC), the corpora cardiaca (CC) and the corpus allatum (CA).

i. The median neurosecretory cells (MNC)

The MNC lay in the pars intercerebralis as two groups, one on either side of the

median line, but close to one another, often appearing as a single bunch. They are placed just below the perineurium and consist of three types of cells : A, B and C.

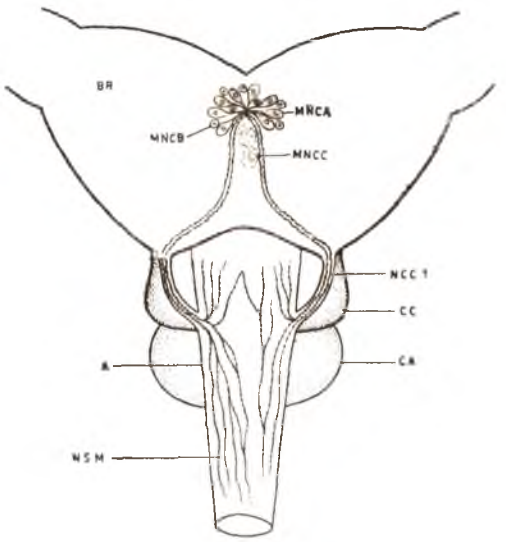

Fig. 1. Diagrammatic representation of the neuroendocrine system of the adult *Dysdercus cingulatus*. A–aorta; BR-brain; CA–corpus allatum; CC–corpus cardiacum; MNCA, MNCB and MNCC A, B, and C cells of pars intercerebralis neurosecretory cell cluster respectively; NCC I–Nervus corporis cardiaci I; NSM– neurosecretory material.

The A-cells : The A-cells are the most conspicuous among the three, because of their stainability characteristics, size, number and colloid content. They appear bluish white *in vivo* and are stainable dark purple with paraldehyde fuchsin (PAF) and resorcin fuchsin (RF), dark blue or greenish blue in performic acid victoria blue (PAVB), and blue black in chrom alum haematoxylin phloxin (CHP). They are 18–22 in number, rounded or oblong, measuring 25μ in diameter, and with 8–9 μ nuclei. They usually contain large quantities of densely stainable colloids. The axons are visible when there is sufficient material in them.

The B-cells : They are 8–12 scattered among the A-cells but most of them situated medially. They are only 8μ in diameter but are longer, about 22μ, with 6–8μ nuclei. They faintly stain purple with RF, and pink with CHP. The axons are not traceable.

The C-cells : They are four in number and occur between the two groups of A-cells and are elongated, 13 – 30μ. They are visible only faintly either with PAF or CHP, but not stainable with PAVB. The nuclei are 8–9 μ ; there is very little amount of secretory material in their cytoplasm.

ii. The neurosecretory pathway

The axons of the A-cells on either side form a bundle and converge to mid dorsal region of the brain where they cross each other. Subsequently they run posteriorly parallel to one another for a short distance, then diverge, emerging from the posterior region of the protocerebrum as Nervi corpori cardiaci, corresponding to NCCI of the other insects. These nerves run free for a short distance, then bypass the CC running above them and ultimately entering the aorta wall at the level of the CA. These nerves profusely branch in the wall of the aorta, the fibres running backwards and forwards in its wall. The fibres have a beaded appearance due to the accumulated secretory material. All these fibres in the aorta forming the neurohaemal organ appear to be derived from the A-cells only.

iii. Corpora cardiaca (CC)

These are a pair of triangular bodies situated behind the brain, 60–90 μ, attached to the aorta ventrolaterally. They appear bluish white *in vivo*. Posteriorly they are attached to the CA.

The cells of the CC are distributed mostly along the ventral region. The dorsal

part, which is close to the aorta, is mostly made of connective tissue. Two types of cells are distinguishable in the CC : The chromophil cells are larger, ovoid or pear shaped with tapering ends, distributed at the centre of the CC and along the ventral region. These cells are 14–18 μ with centrally located 8–12 μ nuclei with fine chromatin and distinct nucleoli. The chromophobe cells are smaller, 8 μ, with poorly stainable cytoplasm. They are with 6 μ, chromatin rich nuclei and are distributed along the dorsal region of the CC and among the larger secretory cells. Axonal fibres of neurosecretory cells are not detected in the CC. There is also connective tissue among the cells. There is no neurosecretory material (NSM) originating from the brain, in the CC.

iv. Corpus allatum (CA)

The CA in this animal is usually unpaired, associated with the ventral wall of the aorta. Its anterior portion is fused with the posterior part of the CC and with the aorta wall. When paired, it is attached to the CC of the corresponding side. The allatum is either transparent or translucent ; the cells are closely packed, with distinct cell boundaries. The nuclei are rounded or elliptical, with clear nucleoli. Chromatin granules are arranged peripherally in the nuclei. There is no neurosecretory material (NSM) in the CA.

2. Changes in the endocrine system of the normal female with vitellogenesis

i. The neurosecretory cells : Quantitative changes in the neurosecretory content

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EXPLANTATION OF FIGURES

Fig. 2. Cephalic neuroendocrine system with anterior portion of th aorta. A–aorta with axonal fibres (AS) of A–cells (MNCA); CA–corpus allatum; NCC I–Nervus corporis cardiaci I; P–Point of convergence of the axons from different neurosecretory A–cells (whole mount, formol saline, PAVB).

Fig. 3. Section of the brain showing A–cells (MNCA) and B–cells (MNCB) (BOUIN'S fluid, CHP).

Fig. 4. Cephalic neurosecretory system showing A–cells (MNCA) and C-cells (MNCC) (whole mount, BOUIN'S fluid, PAF).

Fig. 5. Section of the corpus cardiacum (CC) and corpus allatum (CA) with aorta (A). LC–large chromophil cells; SC–small chromophobe cells (BOUIN'S fluiid, HE).

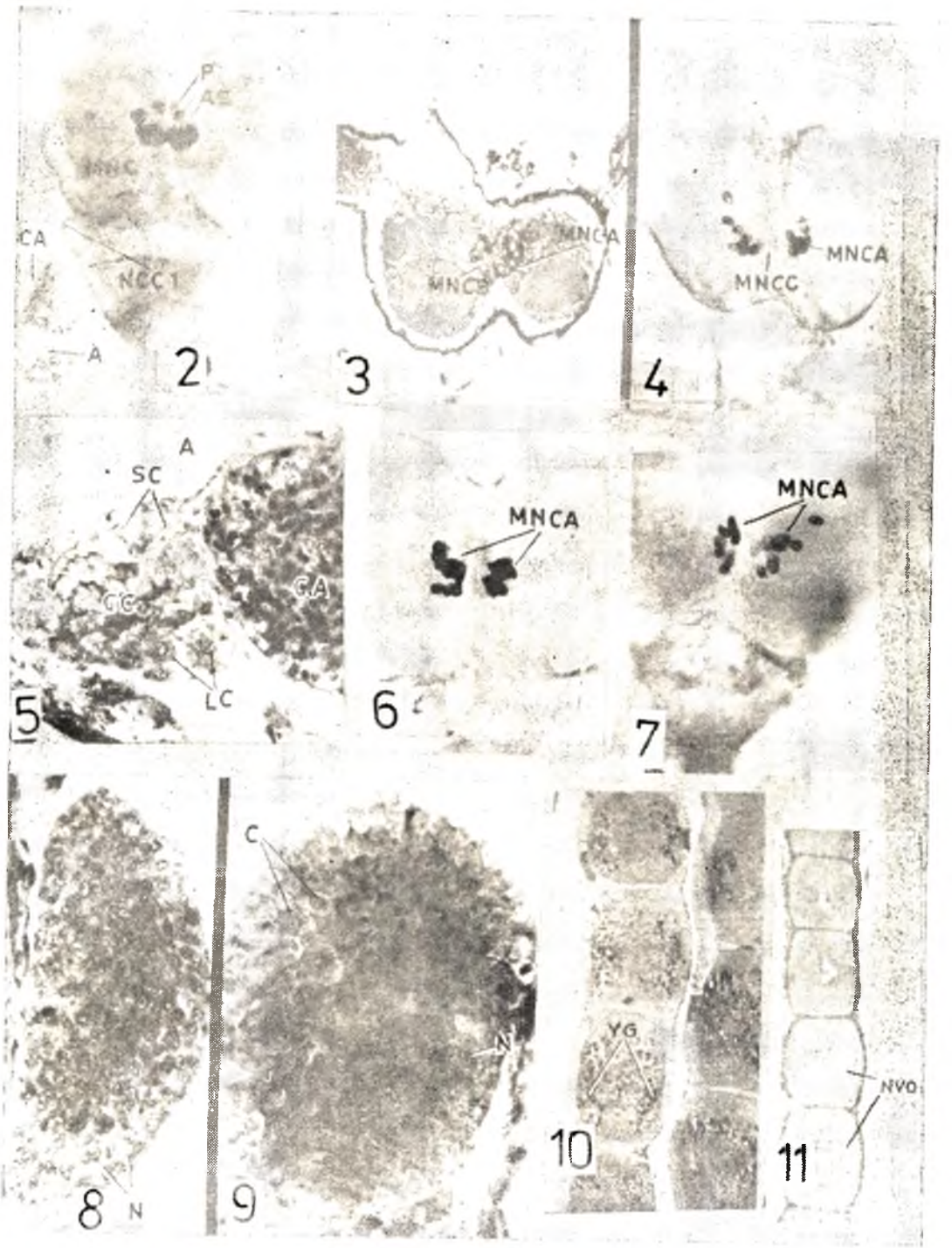
Figs. 6 & 7. Whole mount of the brain showing the A–cells (MNCA) on days 3 and 5 respectively. Cells are maximally filled with secretion on day 3 (BOUIN'S fluid, PAVB).

Figs. 8 & 9. Section of the corpus allatum on days 1 and 4 respectively, showing the difference in size of the organs, their cells and the nuclei. C–cell bodies; N-nuclei. Cells are closely packed in the allatum of one day old animal (BOUIN'S fluid, HE).

Figs. 10 & 11. Ovaries of control and allatectomised animals respectively, three days after the operation. NVC–oocytes without any yolk granules; YG–yolk granuls (BOUIN'S fluid, HE).

Figs. 12 & 13. Section of the ovariols four days after allatectomy and of control ovarioles respectively. FC–mononucleate small follicle cells; BFC–large, binucleate follicle cells; NVO–oocytes without yolk granules; YS–yolk granules. Large spaces may be seen among follicle cells in the control ovarioles with corpus allatum (BOUIN'S fluid, HE).

Figs. 14 & 15. Sections of corpus allatum four days after extirpation of MNC, and of its control respectively. Nuclei (N) are small and closely packed in experimental animal (BOUIN'S fluid, HE).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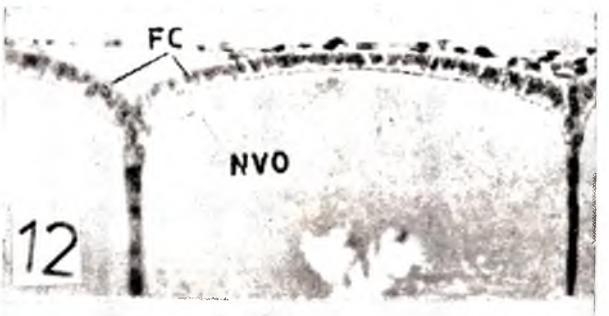
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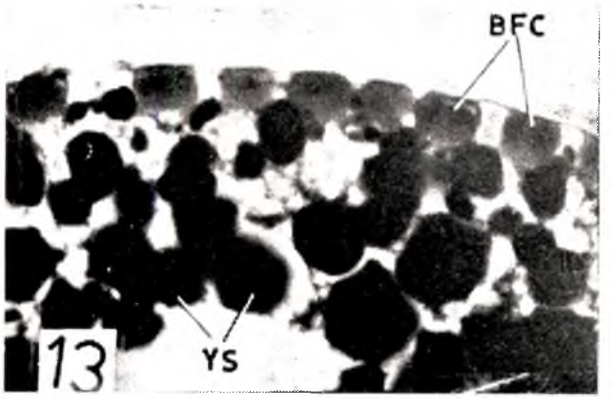
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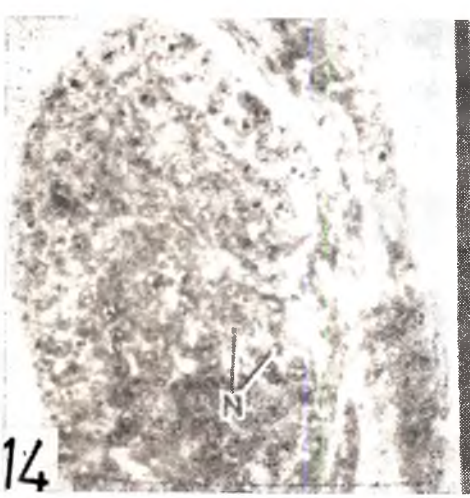
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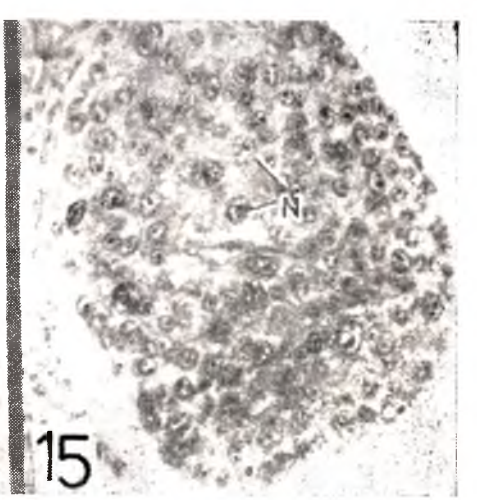
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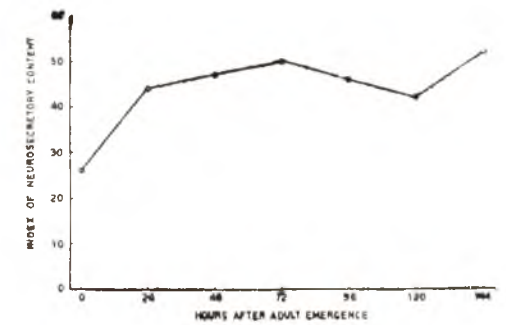
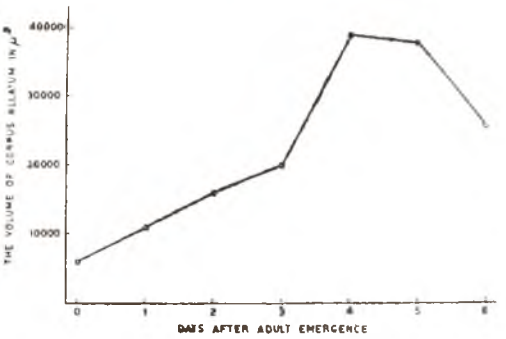
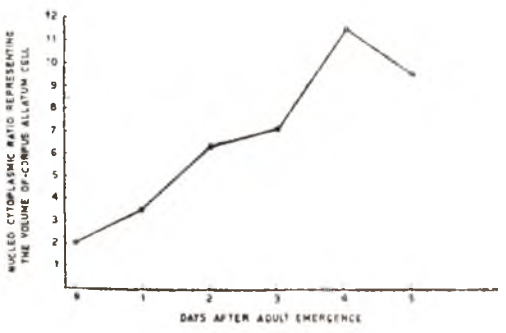
of the A-cells occur during the first gonotrophic cycle. However, these changes are not uniform in all the cells of the animal. So these changes are here represented as neurosecretory indices. The neurosecretory index of the animal during the first gonotrophic cycle is represented in Fig. 16. Measurements of the ovaries are given in Table 1. It may be seen that ovariole length and oocyte size increase with increase in neurosecretory index. The index is lowest in newly moulted animals and is maximum on the third day (Fig. 6), coinciding with peak vitellogenic activity. Again it registers a slight fall on fifth day (Fig. 7). However, it was found that nuclear size decreases with increasing accumulation of NSM in the MNC. Cells with little colloids have nuclei of 13.5 μ of average maximum diameter, whereas in the cells loaded with colloids they measure 9.5 μ. The partially filled cells have nuclei of 11.5 μ size.







ii. Corpus allatum : Changes in the volume of the CA and that of the CA cells are shown in Figs. 17 & 18. Both reach maximum on day 4, when the nuclei also appear to be largest (Figs. 8 & 9).

3. Results of extirpation of endocrine organs on ovaries

i. Extirpation of neurosecretory cells : Histology and histochemistry of vetellogenesis of the normal ovaries of *Dysdercus cingulatus* have been briefly given by JALAJA & PRABHU (1976 a), which is essentially in agreement with *Dysdercus fasciatus* worked out in detail by BRUNT (1971). Some

Fig. 16. (top) showing the change in the quantity of neurosecretory content in the brain during the first gonotrophic cycle. The cells were grouped on one to three scale based on the quantity of neurosecretory content in the cells. The quantity multiplied by the number of cells in that group gave the neurosecretory index of that animal. Each value in the graph is the average of not less than five individuals.

Fig. 17. (middle) showing the change in volume of the corpus allatum during the first gonotrophic cycle. Values represent the average of observations from at least five animals.

Fig. 18. (bottom) showing the change in volume of corpus allatum cell during the first gonotrophic cycle. Values represent the average of observations from at least five animals.

TABLE 1. Relation between age of insect and size of ovarian tissue in normal *Dysdercus cingulatus*.

(Values represent the mean of the measurements on the ovarioles)

Age, hours after emergence	Length of the ovariole (in mm)	Length of the germarium (in mm)	No. of oocytes in the vitellarium (nearest whole number)	Size of the anteriormost oocyte in the vitellarium (in μ)	Measurements of the posteriormost occytes in the vitellarium (in μ)
0	3.4	1.2	4	75 × 115	170 × 200
24	3.5	1.3	6	130 × 115	180 × 175
48	4.8	1.3	8	190 × 200	300 × 350
72	7.2	1.5	9	480 × 500	600 × 700
96	8.9	1.1	9	975 × 1050	950 × 1650
120	12.0	1.0	9	800 × 1300	800 × 1300

TABLE 2. The effect of extirpation of median neurosecretory cells on growth of the ovary.

(Measurements represent average of values from 10 females for each age group)

Age of the insect (hours after emergence)	Length of the ovariole (in mm) (corrected to mm)	No. of oocytes in the vitellarium (corrected to whole number)	Measurements of anteriormost oocyte in the vitellarium (in μ) (corrected to multiples of 5)	Measurements of posteriormost oocyte in the vitellarium (in μ) (corrected to multiplies of 5)	Follicle cell size of the anterior oocyte (in μ) (corrected to μ)	Follicle cell nuclei of the posterior cocyte (in μ) (corrected to μ)
24 Exp.	4	6	130 × 115	170 × 175	8 × 5	7 × 5
Con.	4	6	130 × 115	180 × 175	8 × 5	7 × 5
48 Exp.	5	6	175 × 200	200 × 300	11 × 8	10 × 8
Con.	5	8	190 × 200	300 × 350	11 × 11	10 × 8
72 Exp.	5	6	180 × 200	250 × 300	11 × 8	10 × 8
Con.	7	8	480 × 500	600 × 700	12 × 11	11 × 11
96 Exp.	5	6	180 × 200	250 × 300	11 × 8	10 × 8
Con.	8	8	975 × 1050	950 × 1600	12 × 11	11 × 11
120 Exp.	4	6	170 × 200	200 × 250	11 × 8	10 × 8
Con.	10	8	800 × 1300	800 × 1300	13 × 12	11 × 12

observations on the effect of extirpation of MNC on vitellogenesis in *D. cingulatus* have already been reported elsewhere. Extirpation inhibits vitellogenesis either partially (JALAJA *et al.*, 1973), or, when done sufficiently early inhibits vitellogenesis completely (JALAJA, 1974). The effect of extirpation of MNC on ovaries is given in Table 2. Extirpation of MNC also results in decrease in size of the corpus allatum, corpus allatum cells and their nuclei (Figs. 14 & 15).

ii. Extirpation of corpus allatum : A brief report of the effect of extirpation of CA on vitellogenesis has already appeared (JALAJA & PRABHU, 1976 b). Further work shows that the length of the ovarioles, the size of the follicle cells as well as follicle cell nuclei, and the size of the oocytes in the vitellarium remain small as compared to the corresponding control subsequent to extirpation of CA (Table 3 ; Figs. 10 & 11). In insects in which allatectomy is complete, inhibition of vitellogenesis is also complete. Basal oocytes of the animals five days after allatectomy begin to resorb. In the germarium the trophocytes in the posterior region start disintegration, lumps of chromatin appearing there. Resorption is almost complete by 10 days after allatectomy when only an empty ovarian tube remains.

Significant differences are also noticed in the follicle cells. Follicle cells around the vitellogenic oocytes are large binucleated and round, 11–13 μ, with extracellular spaces among them during later stages (Fig. 13). In the ovaries of the allatectomised insects, follicle cells are smaller, measuring 8×9 μ, with no clear intercellular spaces among them (Fig. 12). No protein, carbohydrate or lipid yolk granules are found in the ovary of allatectomised female whereas in the controls, yolk deposition starts at the end of 2nd day or beginning of 3rd day after adult emergence. The larger disintegrated

TABLE 3. The effect of allatectomy on the ovary. Measurements represent average of values from six females for each group.

Age of the insect (hours after allatectomy)	Length of the ovariole in mm (corrected to mm)	No. of oocytes in the vitellarium (corrected to whole number)	Size of the anteriormost oocyte in the vitellarium (in μ) (corrected to multiples of 5)	Size of the posteriormost oocyte in the vitellarium (in μ) (corrected to multiples of 5)	Size of the follicle cell of the posteriormost oocyte (in μ) (corrected to μ)	
					Follicle cell	Nuclei
72 Exp.	5	7	175×200	250×300	10×8	8×8
Con.	8	8	480×500	600×700	12×11	11×11
120 Exp.	4	6	170×200	200×250	10×8	8×8
Con.	10	8	800×1300	800×1300	13×12	11×11
168 Exp.	4	5	170×200	200×250	10×8	8×8
Con.	Eggs laid	Nil	.. ..	.. ..	.. ..	.. ..
240 *Exp.	4	Nil	.. ..	.. ..	.. ..	.. ..

* Control values not given as next gonotrophic cycle already started in these and hence cannot be compared with.

chromatin granules in the germarium of the allatectomised animals contain abundant RNA, DNA and proteins however.

4. Results of implantation of endocrine glands into animals from which endocrine organs were previously extirpated

i. Implantation of MNC into animals from which MNC were already extirpated : It has already been briefly reported that implantation of MNC into animals whose MNC were previously extirpated, reverses the effect of extirpation, as most of them develop eggs subsequent to implantation (JALAJA, 1974). Further histological and histochemical studies show that their ovaries are comparable to normal ovaries in which vitellogenesis is taking place.

ii. Implantation of CA in animals from which MNC were previously extirpated : Hosts from which MNC were previously extirpated and into which CA is implanted subsequently, show swelling of the abdomen two days after implantation of CA. By 5th day after implanation the insects lay eggs.

iii. Implantation of MNC into allatectomised insects : Implantation of a complete cluster of MNC or even two clusters into allatectomised hosts does not restore egg maturation even ten days after implantation. Histological picture is comparable to that of the control ovaries. Oocytes get resorbed at the end in both groups.

iv. Implantation of CA into allatectomised insects : When two CA are implanted into allatectomised insects two days after allatectomy, swelling of the abdomen is noticed two days after implantation. Subsequently the animals lay eggs. Ovaries of the control animals are however in the previtellogenic condition, and later oosorption is initiated in them.

5. Effect of allatectomy and extirpation of MNC from older insects

Extirpation of MNC in insects 10–30 hrs after adult emergence inhibits vitellogenesis to a certain extent. The ovary of the experimental animals becomes shorter and the number of oocytes undergoing vitellogenesis are fewer when compared to the controls, depending upon the time extirpation is carried out after emergence. Extirpation after this period does not prevent normal maturation of the oocytes of the first gonotrophic cycle.

Allatectomy in insects just after completion of two days after emergence inhibits vitellogenesis in some, while in others there is no inhibition. Allatectomy after that period results in normal development of oocytes in all animals, during the first gonotrophic cycle.

DISCUSSION

Endocrine system of *Dysdercus cingulatus* as revealed from the present studies consists of the compact cluster of median neurosecretory cells of pars intercerebralis composed of A, B and C cells, the paired corpora cardiaca and the median corpus allatum, with nervi corporis cardiaci corresponding to NCC I of other insects bypassing the CC and ramifying in the anterior portion of the aorta wall forming a neurohaemal organ. The CC has two types of cells, the chromophil and the chromophobe, in addition to the connective tissue cells. It is now generally agreed that in most if not all heteropterans, the aorta wall is the neurohaemal organ (see TIWARI & SRIVASTAVA, 1975), and the present findings support this view. However, the MNC in these animls appear to be made up of more than one type of cells compactly arranged together. The B-cells stainable pink are

present in *Dysdercus cingulatus*, scattered among the A-cells. In addition there are C-cells which differ from A and B types because of their shape, stainability and size. This is contrary to the findings in *Dysdercus koenigii* made by TIWARI & SRIVASTAVA (1975). However, for the present studies the whole cluster of MNC in *D. cingulatus* has been treated as a single category, as it is not possible to isolate one group from the rest for experimental purposes. Also, unlike *D. koenigii* (TIWARI & SRIVASTAVA 1975), in *D. cingulatus* present studies reveal that CC is made up of two types of cells, the chromophobe and the chromophil types, in addition to the connective tissue. Possibly the large cells of the CC in *D. koenigii* reported by TIWARI & SRIVASTAVA (1975) might be the chromophobe cells. It is to be pointed out that they recognize a difference in the staining behaviour of the anterior and posterior large cells of the CC in *D. koenigii*. The bilobed or the paired condition of the CA reported in *D. koenigii* by TIWARI & SRIVASTAVA is also seen in *D. cingulatus*, but this does not appear to be of much significance. We have also not noted any NSM of MNC either in the CC or CA of *D. cingulatus* as in *D. koenigii* and in many other heteropterans.

Present studies involving changes in the neuroendocrine complex of the normal female during he first gonotrophic cycle show that the neurosecretory index which is indicative of the total neurosecrtory content of the MNC in an animal, increases as vitellogenesis proceeds. However, the size of the nuclei of the neurosecretory cells which is proportionate to the activity of the cells decreases with the increase of the neurosecretory content in the cells. It is now well recognized that the quantity of the colloids in the MNC is not indicative of the activity of the cells. This problem has been discussed by ENGELMANN (1970) and HIGHNAM (1962). On the basis of data from the nuclear size it appears that the MNC in *D. cingulatus* are active at the beginning and elaborate and release considerable quantity of NSM from the cells. By the time vitellogenesis starts NSM necessary for vitellogenesis has already been released into blood. So the activity of the MNSC decreases, synthesized colloids are being stored and MNC get filled up with colloids when vitellogenesis is already completed. The fact that extirpation of MNC after 30 hrs has no effect on vitellogenesis shows that NSM necessary for vitellogenesis has already been released into the blood stream by then. The material elaborated after that is stored in the perikarya which then get filled up and the secretory activity dwindles resulting in loaded cells with smaller nuclei.

The volme of corpus allatum as a whole as well as that of the corpus allatum cells increases with progress of vitellogenesis. Nucleus also increases in size. This would indicate that corpus allatum continues to increase in activity with progress in vitellogenesis. Extripation experiments show that CA hormone sufficient for vitellogenesis has been released into the blood stream by two days after emergence. so the higher volume of CA and its cells after this critical period might indicate storage of hormone in the CA, as in the MNC. The problem of storage, release and accumulation of hormone vs size of the CA and its activity in insects have been discussed by ENGELMANN (1970) and by DE WILDE & DE LOOF (1973).

Present studies have shown that the critical period for removal of MNC without affecting the vitellogenesis in *D. cingulatus* is 30 hrs after emergence and for CA, two days. Till then MNC and CA are necessary for proper vitellogenesis. After these periods both these organs can be

removed without affecting vitellogenesis. The present studies also show that MNC and CA are necessary in the normal animal for vitellogenesis, and that effects can be duplicated by either of the experiments. The effects can of course also be reversed by reimplantation of the extirpated organs. In addition the present studies reveal that implantation of active CA from an animal into one from which MNC have been previously extirpated, will induce vitellogenesis, whereas implanation of MNC into allatectomised animal cannot induce vitellogenesis in them. This also shows that the effect of MNC is mediated through the CA and that the function of the MNC is to activate the CA to produce its hormone, which directly stimulates vitellogenesis in *D. cingulatus* as in *Locusta migratoria* (Mc CAFFERY, 1976) and in *Danaus plexippus* (BARKER & HERMAN, 1973). This is in step with the views of BELL & BHOM (1975).

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LINEAR GROWTH OF EYES IN THE DESERT LOCUST, *SCHISTOCERCA GREGARIA* (ORTHOPTERA, ACRIDIDAE)

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(1) Linear growth in length and width (straight line distances) of eyes in *Schistocerca gregaria* (FORSKAL) in green, phase *solitaria* hoppers (stages I—V) and adults, was studied. With each moult the mean length increases in males from 1.1738 mm in stage I to 3.5840 mm in adult, and in females from 1.1757 to 4.3345 mm. The corresponding values for eye-width are: males 0.5296 and 2.3200 mm; females 0.5442 and 2.7127 mm. (2) The increase in length between two successive stages varies from 1.14—1.41 times for length and 1.23—1.45 times for width. Except in stage I (where no difference is noticeable), the increase in both length and width is generally greater in females than in males. (3) The total mean increase from stage I to adult is, in the two sexes, 3.05 and 3.69 times in length, and 4.38 and 4.98 times in width (being 35%—43.6% higher in width). (4) The ratio Width/Length increases from below 0.5 in stage 1 to well above 0.5 in adults (males: 0.4518 to 0.6492; females 0.4646 to 0.6274). No sexual difference is noticeable in the ratio. (5) As a result of allometric growth (which is greater in width) the eye-shape changes from elongate-oval in stage I to broadly oval in adults. (6) The theoretical implications of the rate of growth are discussed.

INTRODUCTION

Linear growth rates in insects have been studied by several workers and some empirical rules formulated (for a summary see WIGGLESWORTH, 1972). Thus, Dyar's rule for head-width postulates an increase of 1.4 times with each moult, but this varies widely in different species, and even within a species, from about 1.10 to 1.96. PRZIBRAM's rule postulates a theoretical increase of 1.26 times for liner parts, but this too is not always realised in practice.

Linear growth of the body and its parts has been studied in several grasshoppers (Acridoidea) (vide below, Discussion), but the eyes, which provide excellent material, remain unstudied except in *Nomadacris septemfasciata* (BURNETT, 1951). In the present account we present the result of our study on linear growth of eyes (length and width) in the Desert Locust, *Schistocerca gregaria* (FORSKAL) (Orthoptera, Acrididae) and have discussed its significance.

MATERIAL AND METHODS

Eyes of green, phase *solitaria* hoppers, bred singly in the laboratory and also obtained in the field, were measured with an eye-piece micrometer under a binoular for maximum length and maximum width (straight line distances bewteen two parallels marking the extreme limits, excluding the ocular sclerite). The data were statistically analysed.

RESULTS

Change in eye-size and its ratios

Size: On the basis of five hopper stages (excluding the "intermediate" stage or vermiform larva immediately on hatching from

TABLE 1. Statistical parameters of postembryonic growth in length of eyes in *Schistocerca gregaria*.

Stage	n	Range (mm)	Mean±SE (mm)	SD	CV	Multiple of previous stage	't' value for sex difference (and its significance)
			Males				
I	29	1.12–1.28	1.1738±0.0080	0.0431	3.67	..	..
II	12	1.12–1.52	1.3967±0.0276	0.0957	6.85	1.19	..
III	18	1.68–2.40	1.9467±0.0484	0.2053	10.55	1.39	..
IV	15	2.32–2.64	2.5067±0.0289	0.1118	4.46	1.29	..
V	9	2.96–3.60	3.1556±0.0694	0.2083	6.60	1.26	..
Adult	5	3.36–4.00	3.5840±0.0970	0.2617	7.30	1.14	..
Total increase from stage I	..	..	..	..	..	3.05	..
			Females				
I	38	1.00–1.28	1.1757±0.0096	0.0585	4.97	..	0.15 (NS)
II	20	1.44–1.60	1.4900±0.0112	0.0500	3.36	1.27	3.13 (**)
III	24	1.68–2.48	2.0200±0.0487	0.2385	11.81	1.36	1.04 (NS)
IV	21	2.08–3.04	2.8476±0.0468	0.2145	7.53	1.41	6.20 (***)
V	14	3.12–3.76	3.4286±0.0523	0.1956	5.70	1.20	3.19 (**)
Adult	11	4.00–4.80	4.3345±0.0746	0.2474	5.71	1.26	6.65 (***)
Total increase from stage I	..	..	..	..	..	3.69	..

Not significant : NS
Significant at : P=1%, **; 0.01%, ***

Abbreviations used: CV—coefficient of variation; df—degree of freedom; F—variance ratio among means; MS—mean of squares; n—number of samples; P—level of probability; SD—Standard Deviation; SE—Standard Error; SS—Sum of squares; 't'—Student's 't' value.

the egg), the mean length of eyes steadily increases with each moult, in males from 1.1738 mm in stage I to 3.5840 mm in adult, and in females from 1.1757 to 4.3345 mm. The corresponding values for mean width are: males 0.5296 and 2.3200 mm; females 0.5442 and 2.7127 mm (Table 1). The increase in length between successive stages is 1.14—1.41 times for length and 1.23—1.45 times for width, without any apparent regularity except that the length increase in the middle period (i.e., between stages II and III, and III and IV) is greater than in the more peripheral ones. The greatest variation in length was observed in stage III (males 10.55%, females 11.81 %), and similar is the case for width (males 13.01%, females 12.99%). Occasionally, the rates of growth may differ in the right and left eyes, resulting in asymmetry. Thus, in a stage III female hopper, while the left eye was normal the width increase in the right eye was faster, resulting in a semiround eye (Fig. 1, H).

Ratio Width/Length: The mean ratio Width/Length gradually increases from 0.4518 in stage I to 0.6492 in adult in males, and 0.4646 and 0.6274 respectively in females (Table 3), showing that the increase in

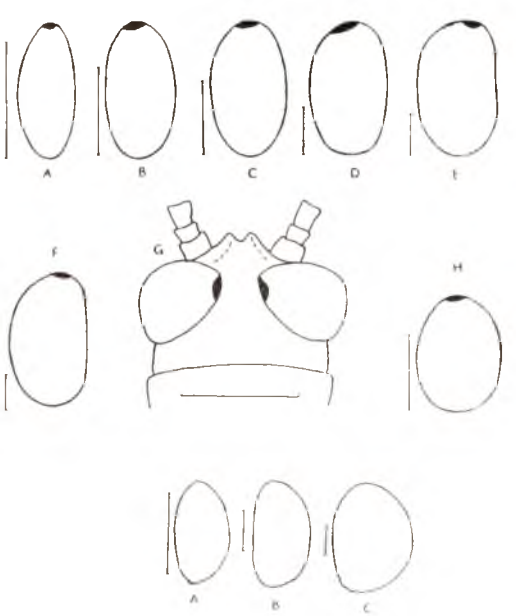

Fig. 1. (first and second rows) *Schistocerca gregaria*, outlines of eyes, in lateral view (females, phase *solitaria*), to show linear growth (Scale 1 mm).

A—1st stage hopper; B—2nd stage; C—3rd stage; D—4th stage; E—5th stage; F—adult; G—1st stage (head, in dorsal view); H—3rd stage, an abnormally wide right eye; the left eye was normal as in C.

Fig. 2 (third row) *Nomadacris septemfasciata*, phase *solitaria* outlines of left eyes (adapted from BURNETT 1951) (Scale 1 mm).

A—1st stage hopper; B—2nd stage; C—adult.

width is greater than that in length. This increase in relative difference, however, is not quite regular. Analysis of variance showed (Tables 4 and 5) that in males there is no significant difference between stages II, III and IV, and in females between stages III and IV and between IV and V.

Sexual differences (Tables 1—3)

Both length and width show highly significant sexual differences except in stage I hopper where no sexual difference is noticeable. The length is greater in females than in males; the same is true of width except that in stage III also there is no significant difference. The ratio Width/Length shows no significant sexual differences.

CONCLUSION AND DISCUSSION

In the first stage hopper the eyes are elongate oval, the ratio Width/Length being below 0.5 (mean ♂♂ 0.4518, ♀♀ 0.4646). Subsequent growth is greater for width than for length by about 43.6% in males and 35% in females, as follows:—

	Times total increase		
	Length	Width	Difference
Males	3.05	4.38	43.6%
Females	3.69	4.98	35.0%

As a result of this allometric growth (the length increasing about 3—3.75 times, the width by about 4.5—5 times), the shape of the eye changes from elongate-oval to broadly oval (see Fig. 1), the mean ratio Width/Length in adults being well above 0.5 (♂♂ 0.6492, ♀♀ 0.6274). The change of ratio (i.e., eye-shape), however, is not regualar: in males stages II, III and IV do not differ from one anothr, and in females stages III and IV and stages IV and V do not differ from each other. Marked sexual differences are noticeable.

Growth rates of body-length and body-parts for various grasshoppers (Acridoidea) other than *Schistocerca gregaria* have been studied by several workers, e.g., HODGE (1933), SHEPT (1934), KEY (1936), DUARTE (1938), PETERSEN & WEBER (1949), BURNETT (1951), DAVEY (1954), ALBRECHT (1955) CLARK (1957), WIESEND (1957), and PUTNAM & PETERS (1960), with varying results. *S. gregaria* has been studied, by BODENHEIMER (1927, 1929, body-length and weight), BERNARD (1937, internal eye structures),

TABLE 2. Statistical parameters of postembryonic growth in width of eyes in *Schistocerca gregaria*.

Stage	n	Range (mm)	Mean ± SE (mm)	SD	CV	Multiple of previous stage	't' value for sex difference (and its significance)
			Males				
I	29	0.44–0.64	0.5296 ± 0.0073	0.0395	7.46	..	..
II	12	0.72–0.80	0.7267 ± 0.0067	0.0231	3.18	1.37	..
III	18	0.88–1.28	1.0311 ± 0.0316	0.1341	13.01	1.42	..
IV	15	1.20–1.52	1.3200 ± 0.0210	0.0814	6.17	1.28	..
V	9	1.68–2.08	1.7956 ± 0.0424	0.1272	7.08	1.36	..
Adult	5	2.16–2.48	2.3200 ± 0.0506	0.1131	4.88	1.29	..
Total increase from stage I	..	..	..	..	..	4.38	..
			Females				
I	38	0.44–0.64	0.5442 ± 0.0072	0.0441	8.11	..	1.40 (NS)
II	19	0.72–0.80	0.7520 ± 0.0080	0.0358	4.76	1.38	2.18 (*)
III	24	0.88–1.28	1.0733 ± 0.0284	0.1394	12.99	1.43	0.99(NS)
IV	21	1.12–1.76	1.5619 ± 0.0305	0.1400	8.96	1.45	6.53 (***)
V	14	1.76–2.16	1.9257 ± 0.0350	0.1311	6.81	1.23	2.21 (*)
Adult	11	2.48–3.28	2.7127 ± 0.0766	0.2541	9.37	1.41	3.26 (**)
Total increase from stage I	..	..	..	..	..	4.98	..

Not significant : NS
Significant at : P=5%, *; 1%, **; 0.01, ***

TABLE 3. Statistical parameters of the ratio Width / Length of eyes in *Schistocerca gregaria* during postembryonic growth.

Stage	n	Range	Mean ± SE	SD	CV	't' value for sex difference (and its significance)
			Males			
I	29	0.39–0.57	0.4518 ± 0.0068	0.0365	8.08	..
II	12	0.47–0.64	0.5229 ± 0.0128	0.0443	8.47	..
III	18	0.50–0.58	0.5290 ± 0.0065	0.0277	5.24	..
IV	15	0.45–0.59	0.5277 ± 0.0108	0.0418	7.92	..
V	9	0.56–0.59	0.5689 ± 0.0031	0.0093	1.63	..
Adult	5	0.59–0.69	0.6492 ± 0.0196	0.0439	6.76	..
			Females			
I	38	0.38–0.50	0.4646 ± 0.0046	0.0284	6.12	1.61 (NS)
II	20	0.47–0.57	0.5063 ± 0.0053	0.0238	4.70	1.20 (NS)
III	24	0.48–0.57	0.5314 ± 0.0059	0.0291	5.48	0.27 (NS)
IV	21	0.49–0.58	0.5484 ± 0.0057	0.0261	4.76	1.72 (NS)
V	14	0.52–0.59	0.5618 ± 0.0061	0.0230	4.10	1.03 (NS)
Adult	11	0.54–0.80	0.6274 ± 0.0205	0.0678	10.81	0.65 (NS)

Not significant: NS

TABLE 4. Analysis of variance of ratio Width / Length of eyes of *Schistocerca gregaria* during postembryonic growth (Cf. TABLE 3).

	Males				Females			
Source of variation	df	SS	MS	F	df	SS	MS	F
1. Between ratios	5	0.238499	0.047700	37.56 (***)	5	0.291372	0.058274	56.05 (***)
2. Within ratio	82	0.104140	0.001270	..	122	0.126828	0.001040	..
3. Total	87	0.342639	..	..	127	0.418200	..	..

Significant at P = 0.01%, ***

TABLE 5. Comparison of ratio Width / Length of eyes in various stages of postembryonic growth in *Schistocerca gregaria*.

Sex	Stage I	II	III	IV	V	Adult
Male	0.4518	0.5229	0.5290	0.5277	0.5689	0.6492
Female	0.4646	0.5063	0.5314	0.5484	0.5618	0.6274

ROONWAL (1947, eye-stripes), and PRADHAN & BINDRA (1956, surface areas and body-weights).

In eyes in *S. gregaria*, as already stated, the width increases more rapidly than length in successive stages, the mean increase being 1.14—1.42 times for length (total increase 3.05 and 3.69 times in males and females respectively), and 1.23—4.51 times in width (total increase 4.38 and 4.98 times). The ratio Width/Length gradually changes from below 0.5 in stage I to well above 0.5 in adult, resulting in the broadening of the eyes. The only other acridoid species studied in this respect is the Red Locust, *Nomadacris septemfasciata* (SERVILLE) (Fig. 2), by BURNETT (1951) who also found, as in *S. gregaria*, that increase in width is relatively much greater than in length, with the consequent broadening of the eye (as illustrated in his Fig. 2; actual measuremnts, however, were not given). Calculations from his illustrations gave an increase, in successive stages, of 1.04—1.26 times (total 2.96) in length and 0.89—1.94 times (total 4.12) in width, with the ratio Width/Length changing from 0.71 to 1.85. These changes broadly agree, in relative direction, with those in *S. gregaria*.

Some information on the growth of internal eyeparts in *S. gregaria* is provided by BERNARD (1937). Calculations from his data show that broadly, the same pattern of linear growth is followed as in the whole eye. Thus in successive stages the length of retinulae increases 1.1—1.5 times (total increase 4.0 times), and the length of ommatidia 1.1—1.45 times (total increase 3.9 times.)

From the study of postembryonic development of eyes and eye-stripes in *S. gregaria,* ROONWAL (1947, p. 257) had shown that the entire anterior margin of he eye from the dorsal to the ventral tip is the region of active growth, and growth may be regarded as a gradual unfolding at this margin. UVAROV's contention (1966, p. 198) that the "dorsal spot" of eye (a small, darkly pigmented area at the dorsal tip) is the growth area of the eye during hopper development does not appear to have any basis.

Applying PRZIBRAM's rule, BODENHEIMER (1927, 1929) had discussed the probable theoretical basis for these size increases in *S. gregaria,* which were averaged at 1.26 (growth quotiant Q) with each moult, the weight doubling. Each increase of 1.26 times is supposed to be due to a cell division (the weight increased by a factor of 2, giving the value of Q as $\sqrt[3]{2} = 1.26$. Where Q is greater than 1.26, this is believed to be due to a greater number of cell divisions, thus : 1.26, represents one cell division; $(1.26)^2$ (= 1.6), two cell divisions; $(1.26)^3$ (= 2), three cell divisions. We may suppose that when the linear increase is, say, 1.9 times, growth may have involved three cell divisions; and so on. But UVAROV 1966 p. 274) has pointed out that such regularities may not in fact be achieved.

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MORPHOLOGY OF THE HAEMOCYTES OF THE COCKROACH *PERIPLANETA AMERICANA*

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Six morphologically distinct types of haemocytes, the prohaemocytes, plasmatocytes, granular heamocytes, cystocytes, oenocytoids and lamellocyte-like cells are noted in the haemolymph of adult and late instar American cockroach *Periplaneta americana*. Mitotic activity is observed in prohaemocytes and plasmatocytes.

INTRODUCTION

It is known that the haemocytes invade and orient themselves in various patterns within tumorous or tumor-like lesions induced by the severance of the recurrent nerve or decapitation in insects, especially in cockroaches and locusts (HEMA & NAYAR, 1969; SUTHERLAND, 1969; TAYLOR, 1969). But there is no information on the types of haemocytes involved in such tumefactions. Observations on the types of haemocytes involved in this tissue reaction necessitated a thorough knowledge of haemocyte types in the animal. Though nine morphologically distinct types of haemocytes have been described in various species of insects only two types of haemocytes, namely plasmatocytes and cystocytes were distinguished in the adult *Periplaneta americana* (JONES, 1957). The present paper reports six distinct types of haemocytes in *Periplaneta americana*.

MATERIALS AND METHODS

Late instar nymphs and adults of both sexes of *Periplaneta americana* maintained in the laboratory were used for the present study.

Haemolymph was collected by severing the antenna. Smear preparations were made by diluting the haemolymph with 10% formaldehyde saline. The smears were allowed to dry in air, rinsed in distilled water and stained either in GIEMSA's or WRIGHT's stain. Haemocytees were also observed in unfixed and fixed wet preparations using an AO phase contrast microscope. Measurement on haemocytes was carried out using a calibrated ocular micrometer on stained smears.

OBSERVATIONS

Haemocytes of late instar nymphs and adults of *Periplaneta americana* show variation in size and shape. They also vary with regard to nature of nuclear and cytoplasmic inclusions. Six morphologically distinct types of haemocytes are made out. These are : prohaemocyte, plasmatocytes, granular haemocytes, cystocytes, oenocytoids and lamellocyte-like cells.

Prohaemocytes appear as round cells measuring 9μ to 12μ in diameter. In stained preparations the nucleus fills almost the whole cell. The stained cells appear deep purple to dark blue (Fig. 1). Under phase contrast microscope nucleus is distinct (Fig. 2). Prohaemocytes divide frequently apparently by mitosis (Fig. 3).

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Plasmatocytes vary in shape and size: (1) smallest of these cells are round and measure 16μ to 18μ in diameter; (2) oval cells vary from 20μ to 28μ in diameter and 30μ to 40μ in length; (3) fusiform cells range from 14μ to 16μ in diameter and 28μ to 50μ in length (Figs. 4—9). In stained preparations these cells exhibit pink nuclei and pale blue granulated or reticular cytoplasm. The granules stain in shades of pink and show variation in number and size. Mitotic activity appears to be confined to smaller plasmatocytes only (Figs. 10, 11).

Granular haemocytes are round or oval and vary from 18μ to 24μ in diameter (Figs. 12, 13). Cytoplasm stains pale blue. Large number of pink granules present in these haemocytes obscure the nucleus in several preparations.

Cystocytes form round or oval cells ranging from 14μ gto 16μ in diameter (Figs. 14, 15). In smears their cytoplasm is coloured light blue and contains pink granules. Nucleus has dark chromatin bodies in the form of thick stripes. These cells show hyaline cytoplam with cart wheel-like nucleus which is slightly eccentric in position, under the phase contrast microscope. Cystocytes are highly unstable. They disintegrate very quickly after ejecting the cellular inclusions into the surrounding media.

Oenocytoids are round to oval cells with one end characteristically tapering to a point (Figs. 16, 17). These cells vary from 16 μ to 20 μ diameter and 24 μ to 32μ in length. In smears the cytoplasm stains light blue. Cytoplasmic granules are very fine and restricted to the poles of the cells. Small cytoplasmic vacuoles are present in stained preparations. Nucleus stains deep pink and shows an eccentric position.

Lamellocyte-like cells are revealed only under phase contrast microscope (Fig. 18). They have not been identified in stained preparations and hence their measurements

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Different haemocyte types of late instar nymph and adult *Periplaneta americana*.

Fig. 1 Prohaemocyte (× 1100), WRIGHT's stain.
Fig. 2 Prohaemocyte (× 500), Phase contrast.
Fig. 3 Prohaemocyte undergoing division (× 1100), WRIGHT's stain.
Fig. 4 Oval plasmatocyte (× 1100), GIEMSA's stain.
Fig. 5 Spindle shaped plasmatocyte (× 1100), GIEMSA's stain.
Fig. 6 Small round plasmatocyte (× 500), Phase contrast.
Fig. 7 Large round plasmatocyte (× 500), Phase contrast.
Fig. 8 Spindle shaped plasmatocyte (× 500), Phase contrast.
Fig. 9 Spindle shaped plasmatocyte (× 500), Phase contrast.
Fig. 10 Plasmatocyte undergoing division (× 1100), WRIGHT's stain.
Fig. 11 Plasmatocyte undergoing division (× 1100), WRIGHT's stain.
Fig. 12 Granular haemocyte (× 1100), WRIGHT's stain.
Fig. 13 Granular haemocyte (× 500), Phase contrast.
Fig. 14 Cystocyte (× 1100), WRIGHT's stain.
Fig. 15 Cystocyte (× 500), Phase contrast.
Fig. 16 Oenocytoid (× 1100), WRIGHT's stain.
Fig. 17 Oenocytoid (× 500), Phase contrast.
Fig. 18 Lamellocyte-like cell (× 500), Phase contrast.
Fig. 19 Binucleate haemocyte (× 500), Phase contrast.
Fig. 20 Haemocyte with multiple nuclei (× 1100), WRIGHT's stain.

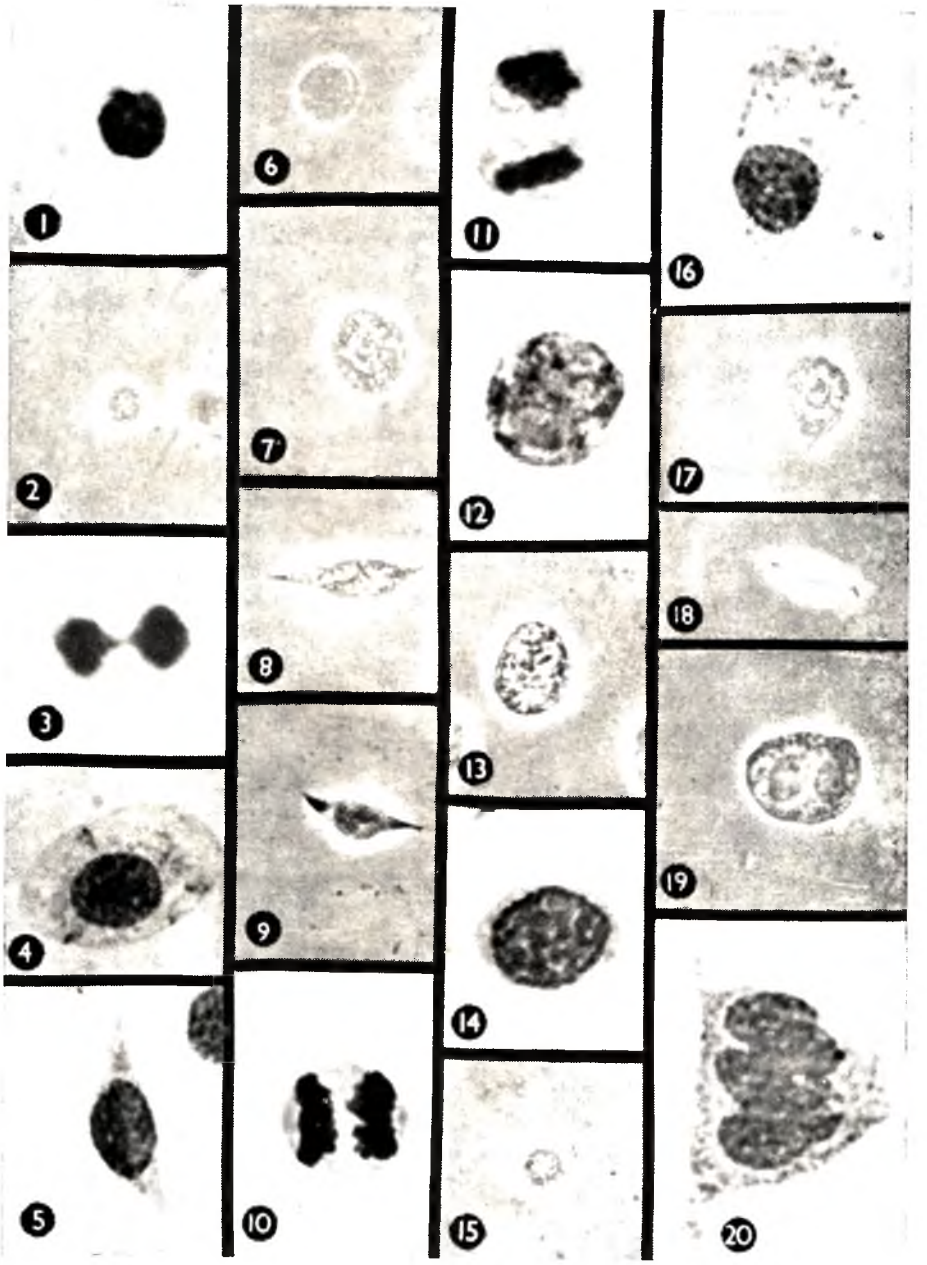
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TABLE 1. Haemocyte types in *Periplaneta americana*.

No.	Type of haemocyte	Cellular features	Mitosis Seen (+) or not (—)	[1] Range of size in μ			
				Diameter		Length	
1.	Prohaemocyte	Round cells. Nucleus fills almost the whole cell.	+	9	12	..	..
2.	Plasmatocyte	Small round or oval or fusiform cells with clear nucleus and granulated or reticular cytoplasm.	+				
		Round cells		16	18	..	..
		Oval cells	—	20	28	30	40
		Fusiform cells	—	14	16	28	50
3.	Granular haemocyte	Round to oval cells, numerous granules in the cytoplasm.	—	18	24	26	30
4.	Cystocyte	Round or oval cells. Eccentric cart wheel-like nucleus.	—	14	16	..	..
5.	Oenocytoid	Round to oval cells: one end is drawn into a point. Eccentric nucleus.	—	16	20	24	32
6.	Lamellocyte-like cells	Narrow cells with boat like appearance and a nucleus.	—		(not measured)		

[1] Average of 20 cells, Corrected to μ

are not recorded. These are narrow boat like cells.

Haemocytes possessing two or more nuclei are present in the haemolymph (Figs. 19, 20). These cells exhibit no definite shape or size. Non-nucleated cytoplasmic masses, minute granules which are termed blood dust or haemoconiae and fat globules are also observed in fixed and unfixed phase contrast preparations.

Table 1 summarises the various characterestics of different types of haemocytes.

DISCUSSION

Present study reveals six types of haemocytes in *Periplaneta americana* comparable to the prohaemocytes, plasmatocytes, granular haemocytes, crystocytes and oenocytoids described in other insects (JONES, 1962) and lamellocytes described in *Drosophila melanogaster* (RIZKI, 1962).

JONES (1957) distinguished plasmatocytes and cystocytes in the haemolymph of adult *Periplaneta americana*. The prohaemocytes, plasmatocytes, granular haemocytes,

cystocytes, oenocytoids and lamellocyte-like cells are also recorded in the present study. ERMIN (1939) indicated earlier that normally only prohaemocytes undergo mitosis in *P. americana*. In the present study prohaemocytes and smaller plasmatocytes of *P. americana* have been observed to divide under normal conditions. In *Tenebrio* and *Prodenia,* prohaemocytes develop into plasmatocytes, cystocytes, spherule cells and adipohaemocytes by gradual, transitional stages (YEAGER, 1945; JONES 1954). GEBHARDT (1932), MELLANBY (1939) and ARNOLD (1952) suggested that the different haemocytes represented different phases in the development of a single basic type. This has not been confirmed by JONES (1962) and the present study reveals that various types could be distinctly recognised in the haemolymph of adults and late instar nymphs of both sexes of *Periplaneta americana*. ARNOLD (1972) in contrast to his earlier concepts (1952) stated that distinct haemocyte types existed in each species which could possibly be utilized to clarify the taxonomy of the group. However, different forms of the same cell type is unlikely to be distinguished from closely related species by light microscopy alone (PRICE & RATCLIFFE, 1974). Granular haemocytes are alike in all insects in general. They are heavily granulated and show no clumping in fresh, unfixed preparations. Cystocytes of *P. americana* possess intranuclear material in the form of stripes and agree with the earlier description (JONES 1957). As in *Tenebrio* (JONES, 1950) typical cystocytes and oenocytoids are observed simultaneously in *P. americana*. HOLLANDE (1911) illustrated haemocytes with lobulated nuclei or with two or more nuclei in a number of insects (JONES, 1962). In *Periplaneta americana* this type of cell possesses well defined nucleus and granulated cytoplsasm. MERCIER (1906), TIEGS (1922), MÜLLER (1925) and MORGANTHALER (1953) claimed amitosis to be the method of multiplication in the haemocytes of *Calliphora* pupae, *Nosonia* and *Apis mellifica* adults (JONES, 1962). Whether the binucleated or multinucleated condttion of the haemocytes seen in the present study has been due to amitosis could not however be confirmed because no other stage of this type of divsion has been observed despite examining several preparations. The presence of cells resembling the laemllocytes described by RIZKI (1962) in *Drosophila melanogaster* and reported for the first time in *P. americana* by GUPTA & SUTHERLAND (1966) are confirmed and illustrated in the present study.

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SCANNING ELECTRON MICROSCOPIC STUDIES OF RESPIRATORY STRUCTURES OF SCORPION *BUTHUS TAMULUS* FABR.

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Scanning electron microscopy of respiratory structures of different arachnids reveal that there is a great deal of variation in the structure of the lamella. Stereomicrographs of the lamellar surface in *B. tamulus* show that it is covered by thin cuticle forming ridges and furrows and presenting reticular network at the free end of the lamella towards the atrial chamber, and bears no bristles as observed under light microscope.

INTRODUCTION

In arachnids, three types of respiratory organs are found: the book lungs, the tracheae and lung sacs (BUCHSBAUM, 1948; PARKER & HASWELL, 1951; KAESTNER, 1956; BARTOS, 1963; LEVI, 1967). Of these, the book lungs of scorpion and other arachnids have drawn the attention of a large number of investigators (BLANCHARD, 1853; LANKESTER, 1885; PAVLOVSKY, 1926; FRAENKEL, 1929; ZOOND, 1934; SNODGRASS, 1952; AWATI & TEMBE, 1956; VYAS & LALIWALA, 1972b; MILL, 1972). Recently we have extended our work on book lungs from light microscopic studies to three dimensional micrographic observtions with the help of scanning electron microscope (VYAS, 1974; VYAS & LALIWALA, 1972a; 1976). The present paper aims to report the observations on book lungs in *Buthus tamulus* with the help of scanning electron microscope. An attempt has been also made to report the structural diversities in the book lungs of related arachnids.

MATERIALS AND METHODS

Live scorpions (*Buthus tamulus*) were collected from the old residential localities in Ahmedabad. These were maintained in the laboratory. For dissections the specimens were anaesthetized using chloroform. Dissections were performed under stereoscopic binocular microscope. Dissected specimens and dead specimens were stored in formoglycerine preservative (VYAS, 1972) for future use. Book lungs were separated from stored specimens and transferred to 10% KOH solution and were kept for 6 to 8 hours. These were thoroughly washed in running tap water. After removing the muscles the sternites containing book lungs were passed through series of 30, 50 and 70 per cent alcohol and cut through different planes. Further dehydration was done by processing the samples through ethanol-amyl acetate grades. The samples instead of critical drying were air dried and coated with metallic silver in a vacuum coating unit (model. Nano-Tech, Manchester) by keeping the specimens on a rotating stage. A Cambridge S4-10 scanning electron microscope was used for the present study. Direct electron micrographs of selected areas of book lung were taken by attached camera and were enlarged as per requirements.

OBSERVATIONS

From the atrial facet of the book lungs a series of vertically arranged lamellae can be observed (Figs. 1, 2) after removing the underlying connective tissue sheath. The number of lamellae in each book lung ranges from 140 to 150. While on the one hand the lamellae attach to the posterior wall of the pulmonay chamber, their atrial

end remains free (Figs. 1, 3, 4). As in other scorpions the space between two adjacent lamellae in the book lungs of *B. tamulus* is also known as inter-lamellar space. These spaces are continuous with the space of atrial chamber and communicate to the exterior through spiracle as described by STAHNKE (1970). The stereomicrographs of the lamellar surface in *B. tamulus* show that it is covered by thin cuticle forming ridges and furrows. This presents a reticular network at the free end of the lamella towards the atrial chamber (Figs. 4 and 5). In a longitudinal section each lamella forms a hollow tubular structure and does not have partitioned lumen (Figs. 3, 4).

DISCUSSION

The observations on structure of lamellae in *B. tamulus* reported here are comparable to those of *H. fulvipes* observed by VYAS (1974). However, in *B. tamulus* the chitinous bristles are lacking. Although these were reported earlier by AWATI & TEMBE (1956) in light microscopy, the SEM studies reveal nature of cuticle deposition on the lamellar suface. The Figures 3 and 4 illustrate how the ridges and furrows formed on the lateral surface of the lamella present a reticular network at its free end. Another noteworthy feature observed in *B. tamulus* is the absence of epithelial sinus. A study of he structure of lamellae of a house spider reveals that unlike the hollow lamellae of scorpions, the lamellae in spiders (Fig. 6) are of spongy nature. Their intralamellar spaces are traversed by thin filamentous extensions of the lamellar walls. Thus there is a great deal of variation in the structure of the lamella in different species of Arachnida. The differences in their structure may be attributed to the nature of the origin and development of lamella (POHUNKOVA, 1969).

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Fig. 1. Book lung showing stigmata, atrial chamber, connective tissue sheath partly exposed, transversely cut lamellae (× 34).

Fig. 2. Lamellae as viewed from the top after removal of connective tissue in atrial chamber (× 105).

Fig. 3. Free ends of lamellae and interlamellar space (× 335).

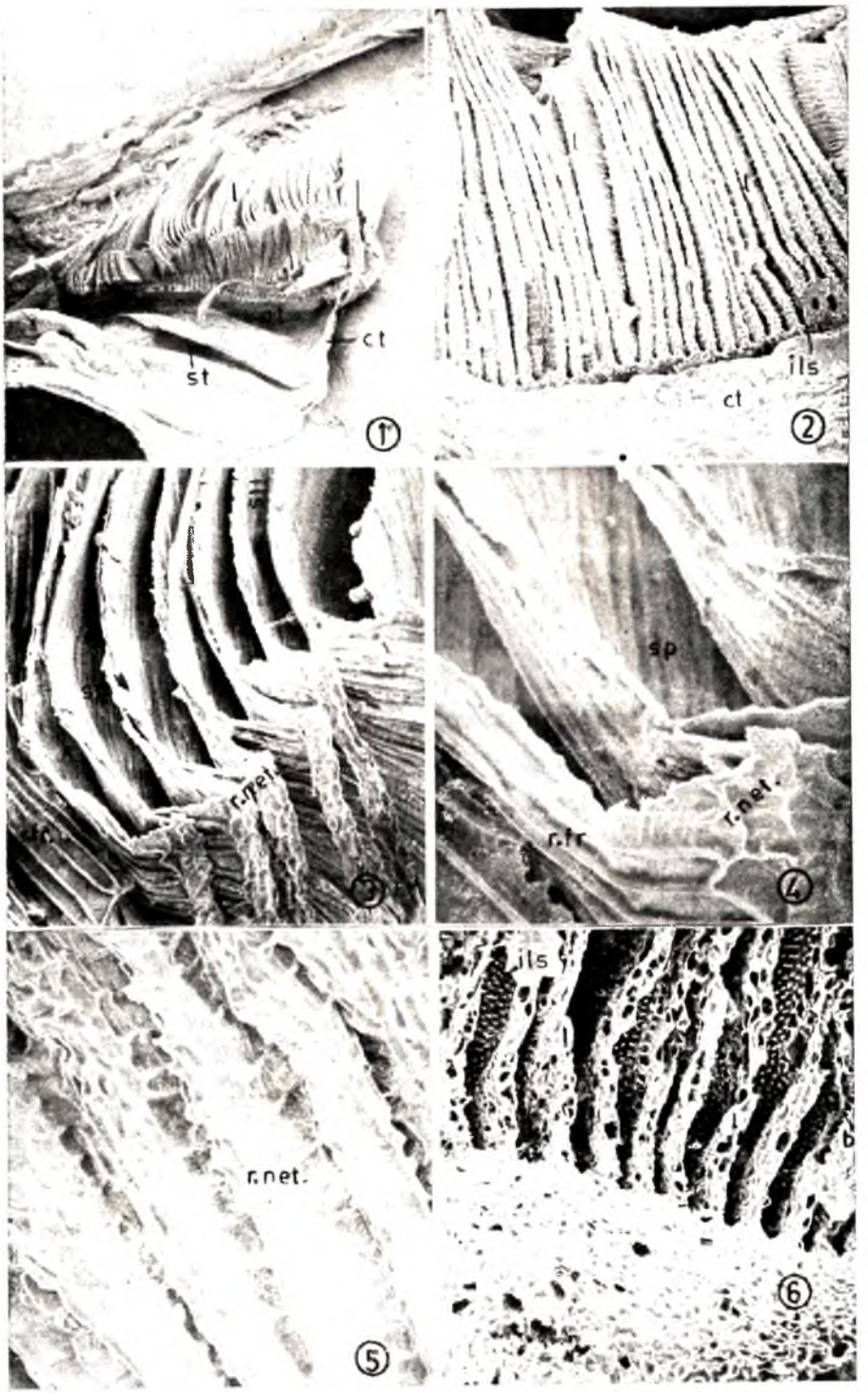
Fig. 4. Lamellar tips in Fig. 3 are further magnified (× 1320).

Fig. 5. Surface of lamellae (2) are further magnified (× 570).

Fig. 6. Structure of lamellae of book lung of spider *Solenops sumitrae* (× 300).
(Figures 1—5 are from tissues of *Buthus*).

Abbreviations used.

at—atrial chamber; br—bristles; ct—connective tissue; ils—interlamellar space; l—lamella; r. fr.—ridges and furrows; r. net—reticular network; sp—space within the lamella; st—stigmata of book lung.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STUDIES ON THE BIOLOGY OF THE MITE *EUTETRANYCHUS ORIENTALIS* (KLEIN) (TETRANYCHIDAE: ACARINA)[1]

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The life history of *Eutetranychus orientalis* (KLEIN) was studied on two host plants, *viz.*, *Rauwolfia serpentina* and *Bauhinia variegata in* the laboratory at an average temperature of 28.64°C and 23.61°C. The duration of incubation, immatures, and life cycle were affected by temperature but not by the host plants. Sixteen generations were observed in a year under laboratory condition.

INTRODUCTION

The polyphagous mite *Eutetranychus orientalis* (KLEIN) has been reported to damage a large number of agricultural, ornamental and medicinal plants (KLEIN, 1936; SAYED, 1942; ATTIAH, 1967; DOSSE & MUSA, 1967; KUBRA BANU & CHANNA BASAVANNA, 1972; LAL & MUKHARJI, 1976 *etc.*). However, only a few references are available on the biology and life history of this species of mite (KLEIN, 1936; SAYED, 1942; KLAPPERICH, 1957; KUBRA BANU & CHANNA BASAVANNA, 1972). Therefore, an attempt was made to study the biology of the mite *E. orientalis* on two different host plants *viz.*, *Rauwolfia serpentina* BENTH. and *Bauhinia variegata* LINN. in the laboratory.

MATERIAL AND METHOD

The rearing method used in the present study was that described by MORISHITA (1954), with slight modifications. Small leaves with petioles 7–8 cm long were selected and thrust erect into the moist sand in a glass tube of size 8 × 3 cm at its centre. The base of the leaf was smeared with the petroleum jelly to form the areas of confinement for the mite. The tube containing the leaf was kept in a plastic jar of 13 × 8 cm size. The jar was covered with a glass chimney. The upper end of the chimney was tied with muslin cloth. The leaf thus remained fresh for 6–8 days after which a fresh leaf was provided. Observations on the development and life history were made thrice daily under binocular microscope.

RESULTS AND DISCUSSION

Nature of damage

All the active stages of the mite *E. orientalis* feed by sucking out the sap from the leaf tissues, due to which whitish or pale speckles appear on the upper surface of the leaf. Thus the leaf turns completely pale instead of natural green and is covered with a layer of fine dust. Tender leaves of *Rauwolfia serpentina* when completely damaged, showed the margins twisted upward (Fig. 1), which was not observed in *Bauhinia variegata*.

Life history

The life cycle of the mite was completed in four active (larva, protonymph, deutonymph and adult) and three quiescent stages (nymphochrysalis, deutochrysalis and teleochrysalis). Each active stage was followed by a short quiescent stage. The morphological structure and the behaviour of different stages of the mite observed in the present study was more or less similar to the findings of KUBRA BANU & CHANNA BASAVANNA (1972).

The duration of different stages were greatly influenced by the temperature but

[1] Part of Ph. D. thesis submitted to Banaras Hindu University.

TABLE 1. Duration of different stages of *Eutetranychus orientalis* on *Rauwolfia serpentina*.

	Incubation period of eggs in days	Duration of the instars in days including quiescent stage			Total duration from egg to adult in days	Life span of adult in days		Fecundity	
		Larva	Protonymph	Deutonymph		Male	Female	Fertilized female	Unfertilized female
[1]Average	3.10	1.35	1.25	1.21	7.01	4.04	8.40	36.33	14.80
[2]Average	5.99	3.04	2.40	2.68	14.11	6.58	12.32	12.36	6.45

[1] Average of five observations at a mean temperature of 28.64°C and R H 76.20%.
[2] Average of five observations at a mean temperature of 23.61°C and R H 60.04%.

TABLE 2. Duration of different life stages of *Eutetranychus orientalis* on *Bauhinia variegata*.

Incubation period of eggs in days	Duration of the instars in days including quiescent stage			Total duration from egg to adult in days	Life span of adult in days		Fecundity	
	Larva	Protonymph	Deutonymph		Male	Female	Fertilized female	Unfertilized female
[1]Average 3.30	1.31	1.14	1.22	6.97	3.24	7.80	37.76	16.39
[2]Average 5.24	3.47	2.61	2.84	14.16	4.16	8.29	13.59	10.26

[1] Average of five observations at a mean tempeature of 28.64°C and RH 76.20%.
[2] Average of five observations at a mean temperature of 23.61°C and R H 60.04%.

not by the host plants (Tables 1 & 2). The average incubation period was 3.10 days and 5.99 days at an average temperature of 28.64 °C and 23.61°C respectively on *R. serpentina,* while the same was 3.30 days and 5.24 days on *B. variegata.*

The larval period including nymphochrysalis was 1.35 days and 3.04 days at 28.64°C and 23.61°C temperatures respectively on *R. serpentina,* and 1.31 and 3.47 days on *B. variegata.*

The protonymphal period including deutochrysalis was 1.25 days and 2.40 days at 28.64°C and 23.61°C temperatures respectively on *R. serpentina* while it was 1.14 and 2.61 days on *B. variegata.*

The deutonymphal period including teleochrysalis was 1.21 and 2.68 days at 28.64°C and 23.61°C temperatures respectively on *R. serpentina* while it was 1.22 and 2.84 days on *B. variegata.*

The average time required for the development from egg to adult was 7.01 days at 28.64°C temperature and 14.11 days at 23.61°C on *R. serpentina* while 6.97 days and 14.16 days on *B. variegata.*

Number of generations

In the laboratory 16 generations were reared in a year. Most of the generations passed in the summer season i.e., from March to June. During winter season in the month of November to January the development was very slow.

Natural enemies

During present study three predators were found feeding on the natural population of the mite *E. oreitalis.* These were *Amblyseius* sp. (Phytoseiidae: Acarina), *Agistemus* sp. (Stigmaeidae: Acarina) and *Scolothrip indicus* PRIESNER (Thripidae).

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Fig. 1. Above, normal plant of *Rauwolfia serpentina* BENTH; below, damaged by *Eutetranychus orientalis* (KLEIN).

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PRELIMINARY OBSERVATIONS ON THE MATING BEHAVIOUR OF *VELARIFICTORUS JAINTIANUS* BISWAS AND GHOSH (ORTHOPTERA : GRYLLIDAE)

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An account of the mating behaviour of *Velarifictorus jaintianus* BISWAS and GHOSH (Orthoptera : Gryllidae) with details about its pre-copulatory behaviour, is given. This is the first such study on an Indian species of the genus *Velarifictorus*.

INTRODUCTION

Only rudimentary knowledge exists about the mating behaviour of crickets of the genus *Velarifictorus* RANDELL 1964. All observations have, so far, been made on *Velarifictorus micado* (SAUSSURE) (ALEXANDER, 1962; ALEXANDER & OTTE, 1967). In the present study observations made in the laboratory on *Velarifictorus jaintianus* BISWAS & GHOSH 1975, are presented. These include: (1) precopulatory behaviour—courtship stances, actions and movements; (2) position assumed during copulation and (3) post-copulatory behaviour. It may be mentioned here that only the male of *V. jaintianus* has been described (VASANTH *et. al.*, 1975), and the description of the hitherto unknown female will be published elsewhere.

MATERIALS AND METHODS

A female (collected on 31 March 1975) and a male (collected on 10 July 1975) were placed in a glass jar 19 cm x 8.5 cm filled with a 3.75 cm layer of fine sand. The top of the jar was covered with a piece of cloth. The sand was moistened with water at regular intervals. Fresh grass, clipped into small bits, was placed inside, and changed periodically. Freshly killed insects-generally beetles-were given as food.

OBSERVATIONS

Two copulations were observed, and these are described below : 1. During courtship the male was seen mounting on the female at least twice (remaining there only momentarily) but the female offered no resistance. One feature that was commonly noticed was the antennation of the female body by the male. In one instance, the male touched the foreleg of the female by his maxillary palpi and mouth parts, but the female quickly withdrew her leg. Another action of the male that elicited a negative response from the female was his attempt to "push" himself beneath her. This resulted in her moving away a little. In another instance the male and female were noticed touching each other's forelegs—in the manner of a "handshake". Whenever the male approached the female he exhibited some sudden jerky motions. After the "handshake" the male moved away. Soon after, the female also moved away and was seen chewing a blade of grass. Within a few minutes the male began singing. Initially, the song consisted of sets of 8—9 short, loud chirps. Between two sets there was generally a brief pause during which the tegmina—held at a 35—45°

angle above the abdomen–were not lowered. But when the pause was longer the tegmina were brought down. Meanwhile, the female began inserting her ovipositor in the sand. At this time, the male, who was 2.5 cm away from the female, facing her, began singing a variation in his earlier song. This variataion can be best described as a set of four to many pulses (each sounding like a sharp "chic") alternated by a trill, occasionally interspersed by the chirps of the original song. At this point, the male turned round and, continuing the song, backed towards the female, who was still vigorously inserting her ovipositor in the sand. When he was only 0.5—1.00 cm away from the female, the latter quickly mounted him. Simulatneously, the song stopped, and a spermatophore was noticed in the rear extremity of the male. This was quickly transferred to the female. Within 5–7 seconds after mounting the female dismounted. 7–10 minutes elapsed between the male's first song to mounting. After the female dismounted the male approached her once or twice, but she moved away.

After 40 minutes the male was noticed approaching the female with the jerky motions of the body. But he only received a discouraging response from the female. Once, when nearly 2.5 hours after copulation, the male went behind the female accompanied by the jerky motions, all the while antennating her tegmina and pronotum, she "kicked" him by the hind leg. This was repeated two or three times. On two other occasions, the female only assumed the "kicking" stance, but did not consummate the action. Even after nearly 6.5 hours succeeding the copulation no further copulation was noticed although, not infrequently, the male went underneath the female but came out soon afterwards. Antennation and palpation of each other's bodies (more on the part of the male) and insertions of the female ovipositor in the sand, were also noticed.

2. During the courtship prior to the second copulation, a white opaque spermatophore was seen protruding from the rear extremity of the male one hour and fifty minutes before copulation. Four minutes after its first appearance a single pumping action of the abdomen brought the spermatophore further outside, and 13 minutes later it seemed to have become clearer and more glassy. About 45 minutes before copulation the male was heard singing for the first time. The song lasted for about ten seconds and was the same as the first song described in the first observation. At this time the male was just behind the female, and his antenna was placed longitudinally on her body. The spermatophore seemed to have receded slightly into his body. A few minutes later it was almost unseen outside. In this courtship too, antennation and palpation were noticed.

Approximately 6 minutes before copulation the male began singing again—a few chirps at a time. This time the female was seen pursuing the male once, and when she made as if to mount upon him, he tunrned round so that his back was towards her head. After some time the male backed towards the female, singing all the while. This song was similar to the one described in the first observation. Prior to this the "handshake" was observed twice. The male then touched the head of the female by the posterior leg. As soon as the male began singing and backing towards the female, the latter began inserting her ovipositor in the sand. Shortly, the song of the male changed to only trilling alternated with "chic-chic". While making the insertions the female moved around in a limited area. So, the male was continually turning around so as to have

his back towards her head. At one stage he touched her head, pronotum, posterior legs, tegmina, abdomen and cerci with his posterior legs. Then, suddenly, the female mounted the male. At once the singing ceased. The spermatophore came out and was transferred to the female. Dismounting occurred 46 seconds after mounting. After dismounting the male and the female stood near each other while the male cleaned his cerci.

DISCUSSION

The courtship sound of *Velarifictorus* does not resemble that of *Gryllus, Acheta* and *Gryllodes* (ALEXANDER, 1961). The present study indicates that the courtship sound of *V. jaintianus* is different from those of *Acheta domesticus* (LINNAEUS) described by ALEXANDER & OTTE (1967) by the fact that in the former it is composed of sets of four to many loud "chic's" alternated by a loud shrill trilling, occasionally interspersed by the chirps of the calling song, while in the latter it consists of soft, rustling pulses interspersed with a regular louder "tick". The male of *V. jaintianus* emits the courtship sound long after contact with the female, but the males of *A. domesticus* "change from the intense chirps of the calling or aggressive sound to a mixture of the pulses from these sounds and the soft, rustling pulses of the courtship sound, almost immediately upon contact (with females)" (ALEXANDER & OTTE, *op. cit.*).

An interesting phase of the pre-copulatory behaviour of *V. jaintianus* which has not so far been recorded in any other gryllline cricket is that prior to mounting, the female was seen inserting her ovipositor in the sand. The mounting was sudden and quick and always followed the insertions of the ovipositor. It may be that this behaviour is essential to make the female receptive for copulation. The method of mounting described by ALEXANDER & OTTE (*op. cit.*) for *A. domesticus* is very different from that observed in *V. jaintianus* in the present study.

Although the jerking motions of the male are found to occur in the courtship of *V. jaintianus* as in an unidentified species of *Gryllopsis* observed by ALEXANDER & OTTE (*op. cit.*), in the latter they seem to constitute the only behaviour necessary to make the female responsive since, being wingless, they are incapable of producing any sound.

According to SPANN (1934), KHALIFA (1950) and ALEXANDER (1961), mating, in *Acheta* and *Gryllus* is repeated as frequently as every 15 minutes whereas in the present study even after 376 minutes no successive copulation was observed following the initial one.

In *Velarifictorus micado*, the only species of the genus in which detailed sexual behaviour has so far been studied, ALEXANDER (1962) observed one copulation to last 3–4 minutes. Although this is much longer than either of the copulations observed by the present author in *V. jaintianus*, ALEXANDER & OTTE (*op. cit.*) quote that "a copulation observed by OTTE, lasted approximately 30 seconds, but the pair separated when touched by another male". Whether the pair would have copulated for a longer duration had there been no interruption is debatable. No turning of the sexual partners to an end-to-end position at separation was observed in *V. jaintianus* as observed by ALEXANDER & OTTE (*op. cit.*).

Copulation in *Teleogryllus* is much longer than in any member of *Velarifictorus* studied so far. In *T. commodus*, it takes 8–10 minutes, with obvious jerking motions

of the male, and in two African species of *Teleogryllus* three copulations observed lasted for 4–4.5 muinutes (ALEXANDER & OTTE, *op. cit.*). In *V. jaintianus* copulations observed lasted 5–7 seconds (one copulation) and 46 seconds (second copulation), and the partners were motionless during copulation.

ALEXANDER & OTTE (*op. cit.*) observed that the male *Acheta domesticus* antennates the female almost immediately after dismounting and "maintains contact with the female, regaining it by a rapid searching behaviour if it is lost". In one of the copulations described in the present study the male approached the female once or twice immediately after dismounting, but the latter moved away. After that the male did not attempt to regain contact with her until after 40 minutes when he again approached her.

The peculiar "kicking" act by the female during the postcopulatory phase in *V. jaintianus* has not been observed in any other Grylline cricket.

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EFFECT OF CORN LEAF APHID INFESTATION ON THE YIELD OF BARLEY VARIETIES

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An experiment to assess the loss caused by the corn leaf aphid, *Rhopalosiphum maidis* to 14 varieties of barley conducted at New Delhi in 1974-75 showed that the aphid population varied widely among the varieties; the lowest and the highest population per shoot was recorded on varieties DL 117 and K 125 respectively. The percentage reduction in grain yield varied between 2.8 in DL 117 and 67.5 in BG 108. The results showed that DL 117 was resistant to the aphid. The reduction in grain yield was primarily due to reduction in the size and the number of earheads while the grain boldness remained unaffected. The appreciable decrease in fodder weight also resulted due to aphid infestation in most of the varieties.

INTRODUCTION

The corn leaf aphid, *Rhopalosiphum maidis* (FITCH) is a serious pest of barley in India. BHATIA *et al.* (1973) and SINGH & BHATIA (1976a, b) have shown that the pest can be controlled economically by the application of certain insecticides. Although based on these trials, avoidable lossess have been estimated, these relate to the particular variety used in the trials. Therefore, an experiment involving barley varieties already released for cultivation or considered to be promising were grown together in order to find out the extent of damage under similar environmental conditions. The results of the experiment conducted during 1974-75 are reported here.

MATERIALS AND METHODS

The experiment was conducted under irrigated conditions during rabi season of 1974-75 at the Indian Agricultural Research Institute, New Delhi in split plot design with three replications and the layout was: main plots, varieties; sub plots, (i) protected (insecticide treated), (ii) unprotected (check).

Fourteen varieties were sown. Each plot consisted of six rows of three metres length. Row to row distance was 25 cm. Seeds were sown at the rate of 75 kg per hectare after a uniform application of 20 kg N & 20 kg P_2O_5 and 20 kg K_2O. Additional 40 kg N was applied in two split doses of 20 kg each as broadcast in standing crop. Field was irrigated five times during the crop season depending upon the soil moisture, rainfall and availability of water. After germination, two rows of one metre length were marked in each plot and plant stand was made constant (30 plants per metre row).

In the unprotected plots of each variety, aphid population was recorded at different intervals, on 20 randomly selected shoots in each plot, starting with the aphid appearance in the field. The protected plots were sprayed with 0.02 % methyl demeton thrice at intervals so as to keep the plants completely free from aphids throughout the crop season. At the harvest time, the following observations were recorded : Number of grain bearing earheads in the two marked rows, number of grains in 10 randomly selected earheads, thousand grain weight, grain and straw yield. The grain yield data were subjected to analysis of variance.

RESULTS AND DISCUSSION

The results are presented in Table 1.

Aphid population on different varieties

The aphids appeared in the first week of February and the population began to

build up on all the varieties reaching the peak during the 1st week of March. By about the 3rd week, the aphids almost disappeared from the crop. Since the population increase and fall followed the same trend on all the varieties, the peak population (March 4) was considered for varietal comparison. The data showed that there was wide variation in the aphid numbers among the varieties. The lowest (7.66) and the highest (142.66) population per shoot was recorded on varieties DL 117 and K 125 respectively with the other varieties ranging in between. The aphid number remained small throughout the season on DL 117 suggesting that the pest was unable to multiply in large numbers on this variety.

Grain yield and its components

There was reduction in the grain yield due to aphid infestation in all the varieties. The differences between the protected and unprotected plots were statistically significant in 12 varieties while in the remaining two, DL 117 and RS 6 with a per cent reduction of 2.8 and 20.1 respectively, the differences were found to be not significant. Though the yield reduction in RS 6 was statistically not significant yet it was large enough to be of economic value. The maximum loss (67.5%) was observed in variety BG 108 and the minimum in DL 36 (25.6).

The data recorded on the number of earheads per metre row indicated that the number of earheads in the protected and the unprotected plots was virtually unaffected in DL 117 while there was moderate to heavy reduction in the unprotected plots of the remaining varieties. Similarly, the data on the number of grains per earhead showed that with the exception of DL 117 there was pronounced effect of aphid infestation on the earhead size in the unprotected plots as compared to the protected. The maximum reduction (51%) was observed in variety BG 108 in which the number of grains per earhead in the protected and unprotected was 33.86 and 16.40 respectively. In general it was observed that in varieties having high aphid infestation, the leaves dried up and the plant remained stunted. Also in cases of severe damage, drying up of the main shoot resulted in production of late tillers bearing earheads devoid of any grain. Further, observations on the boldness of the grain (1000 grain wt) showed that it was unaffected and was more or less similar in the protected and the unprotected plots in all the varieties.

Observations at the time of crop maturity showed that in general the protected plots matured earlier than the unprotected ones. This effect of the insecticidal treatment was most marked in variety DL 117 in which the protected crop matured a week earlier.

Aphid population vs. yield

This experiment was conducted for 4 years (1971-75) but the results obtained in 1974-75 are reported as in the preceding years, the aphid population (SINGH & BHATIA, 1976a, b) did not reach levels high enough so as to bring about significant differences in grain yield. The importance of aphid build up in such studies is evident from the work of STERN (1967) who observed that losses due to *R. maidis* and *R. padi* on barley would be substantial when the population reached above 25–30 aphids per shoot.

Out of all the varieties, DL 117 had the lowest aphid population (7.66 per shoot) and showed negligible grain loss (2.8%). Hence, the variety appears to be resistant to the aphid.

TABLE 1. Average aphid population on 14 varieties of barley (unprotected) and grain and straw yield in protected and unprotected plots during 1974-75 at Delhi.

Variety	Average number of aphids per shoot on March 4, 1975	No. of earheads per metre row		No. of grains per earhead		1000 grain weight (gm)		Grain yield (Q/ha)			Fodder yield (Q/ha)		
		Prot.	Unprot.	Prot.	Unprot.	Prot.	Unprot.	Prot.	Unprot.	Percent loss	Prot.	Unprot.	Percent loss
Ratna	89.73	123.50	67.83	36.10	28.53	34.64	33.20	36.16	22.53	37.7	45.69	28.49	37.7
Jyoti	96.75	87.67	47.00	32.93	22.63	32.44	32.16	40.42	18.33	54.7	47.73	27.16	43.1
DL 3	110.25	81.17	73.83	35.66	22.23	32.44	32.64	41.18	26.07	36.7	49.11	35.18	28.4
DL 69	96.86	95.17	43.50	34.53	24.13	30.80	31.60	40.60	15.80	61.1	38.29	21.82	43.0
RD 31	64.10	90.33	78.83	30.93	23.20	34.00	36.00	42.31	25.69	39.3	49.31	29.80	39.6
BG 25	85.46	131.00	93.00	37.96	26.03	32.70	30.06	39.22	24.22	38.3	35.73	26.22	26.6
BG 108	94.73	97.50	72.33	33.86	16.40	39.00	40.56	49.64	16.16	67.5	56.20	33.16	41.0
RD 102	99.73	116.50	61.33	31.96	24.93	27.30	29.80	38.93	20.56	47.2	43.42	27.89	35.8
RD 118	56.80	93.83	69.50	35.20	24.76	30.54	30.76	44.31	24.84	43.9	51.09	33.38	34.7
DL 36	45.96	92.33	75.83	36.10	26.00	35.50	34.30	41.36	30.78	25.6	45.98	40.91	11.0
K 125	142.66	68.83	60.83	32.83	26.16	35.30	35.24	38.13	26.64	30.1	53.64	37.89	29.4
RD 57	55.73	75.50	68.00	30.63	22.00	33.20	32.36	37.00	21.87	40.9	47.64	32.31	32.2
RS 6	51.60	93.83	62.00	30.56	24.33	31.24	34.24	33.00	26.36	20.1	52.18	37.73	27.7
DL 117	7.66	107.17	107.50	42.33	41.56	29.84	30.56	47.96	46.60	2.8	48.64	45.38	6.7
								Interaction					
								S Em ±		2.47			
								C D 5%		7.13			

Note : (i) Date of sowing 21-12-'74 ; (ii) No. of irrigations 5 ; (iii) Dates of spraying : 1st—13-2-'75, 2nd—26-2-'75, 3rd—14-3-'75.

The size of aphid population had no correlation with the yield loss observed in the varieties. The highest population (142.66) was on K 125 (percentage grain loss 30.1) followed by variety DL 3 (110.25) (loss 36.7). Maximum loss (67.5%) was observed in variety BG 108 (population 94.73) followed by variety DL 69 (loss 61.1 and population 96.86). Thus it was apparent that the varietal suitability for the growth of aphid population was different from its vulnerability to damage. Although some of the varieties had higher pest population yet suffered relatively less in grain yield. This was most marked in variety K 125 and the results suggested that the variety possessed some degree of tolerance to the aphid. However, it needs further confirmation.

There was appreciable decrease in fodder weight due to aphid infestation in most of the varieties.

Overall considerations

Out of the fourteen varieties included in the trial, three—Ratna, Jyoti and RS 6 have been released for cultivation in India while nine—DL 3, DL 36, RD 31, RD 57, RD 102, RD 118, BG 25, BG 108 and K 125 have been identified and are under pre-release field trials. The present results showed that none of these varieties was resistant to the aphid and control measures against the aphid will be necessary if any of these varieties was grown otherwise in years of aphid epidemic significant losses in yield may occur. The idea of including varieties of pre-releasae stage in the present investigations was that when finally released for cultivation, recommendation for aphid control should be issued along with other practices for realizing their yield potential and avoiding losses. The methods for the control of this pest have been reported (BHATIA *et al.*, 1973; SINGH & BHATIA, 1976a, b).

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INSECTICIDAL TRIALS AGAINST MUSTARD APHID, *LIPAPHIS ERYSIMI* KALT (APHIDIDAE: HOMOPTERA)

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Experiments on the control of mustard aphid, *Lipaphis erysimi* KALT were conducted during 1975-76 under agro-climatic conditions of Udaipur, Rajasthan. The soil treatments of aldicarb, disulfoton and phorate @ 1 and 2 kg *a. i.* per ha were effective against aphids over control. However, the yield of mustard obtained from disulfoton (2 kg *a. i.*/ha) treatment was significantly higher than that of other treatments. In another set of experiment, the treatment of malathion gave higher percentage reduction of aphid population than that of endosulfan, sprayed alone or on plants grown on aldicarb, disulfoton and phorate treated soils. The treatment of aldicarb (2 kg *a. i.*/ha) along with 2 sprays of 0.05% malathion was much effective against aphids and also gave higher yeild.

INTRODUCTION

The mustard aphid, *Lipaphis erysimi* KALT is a serious pest on mustard (PRADHAN *et al.*, 1960). In the past, several attempts have been made to cntrol it. Foliar application of several contact insecticides like parathion, malathion, diazinon, nicotine, endrin and BHC (SINGH & SIDHU, 1958, 1959) and of systemic insecticides like manazon and dimethoate (SAINI & CHHABRA, 1961) have shown that yield can be increased considerably by controlling the aphid. Recently NAKAT & PESWANI (1972) found that a single furrow application of disulfoton was efficaceous for more than 109 days against mustard aphid. The present investigations were carried out to find out the effective insecticidal schedule for the control of aphids under agri-climatic conditions of Udaipur, Rajasthan.

MATERIALS AND METHODS

The experiments were laid out in a randomised block design at agronomy farm of College of Agriculture, Udaipur during 1975-76. The whole field was divided into 48 plots, each measuring 2 m × 5 m. There were two sets of experiments; in one set only granular systemic insecticides at the treatment dosages of 1 and 2 kg *a. i.*/ha were applied in soil while in the other set, the application of granular systemic insecticides (2 kg *a. i.*/ha) along with two sprays of contact insecticides (0.05% malathion and endosulfan 800 l/ha) was carried out. The systemic insecticides were appplied in furrow before sowing of mustard while contact insecticides were sprayed on 40 and 55 days old crop. Ten plants from each plot were randomly selected and tagged. The aphid counts (visual) were made on three leaves (lower, middle and upper) of each tagged plant.

RESULTS AND DISCUSSION

It is evident from Table 1 that 20 days after soil treatment of insecticides, the aphid population was significantly lower in all the treatments except control. All treatments proved equally effective. After 40 days of treatment the aphid population started increasing in all the treatments. The treatments of aldicarb, disulfoton and phorate were significantly superior over control. However, aldicarb and disulfoton were equally effective, followed by phorate treatment. The results of present investigations however contradict the findings

TABLE 1. Effect of some soil systemic insecticides on the population of aphids on mustard.

Treatments	Average population of aphids per plant after:		Yield of mustard Q/ha
	20 days	40 days	
Aldicarb			
1 kg *a. i.*/ha	131.0	233.3	0.23
2 kg *a. i.*/ha	107.7	135.7	4.80
Disulfoton			
1 kg *a. i*/ha	126.7	211.3	0.72
2 kg *a. i*/ha	120.3	139.7	6.90
Phorate			
1 kg *a. i*/ha	172.7	438.3	0.11
2 kg *a. i*/ha	176.0	367.0	0.70
Control	391.7	542.7	0.10
C D at P = 0.05	94.15	75.12	0.34

TABLE 2. Efficacy of some systemic and contact insecticides against mustard aphid.

Treatments	% reduction of aphid after 24 hours of :		Yield of mustard Q/ha
	1 spraying (40 days)	2 spraying (55 days)	
Aldicarb (2 kg/ha) + Malathion (0.05%)	95.6	80.0	16.9
Aldicarb (2 kg/ha) + Endosulfan (0.05%)	42.8	61.3	14.6
Disulfoton (2 kg/ha) + Malathion (0.05%)	87.6	70.2	15.4
Disulfoton (2 kg/ha) + Endosulfan (0.05%)	52.0	52.8	13.5
Phorate (2 kg/ha) + Malathion (0.05%)	95.0	75.2	10.0
Phorate (2 kg/ha) + Endosulfan (0.05%)	84.0	78.4	7.3
Malathion (0.05%) +	66.0	69.3	7.1
Endosulfan (0.05%)	49.5	45.6	4.1
Control	Full with aphids		0.09
C D at P=0.05	..	..	1.31

of NAKAT & PESWANI (1972) who reported that a single furrow application of disulfoton 5 G 1.95 g/m row, was efficaceous for more than 109 days against mustard aphid. The yield of mustard obtained from the treatment of disulfoton (2 kg *a. i.*/ha) was significantly higher than that of all the other treatments. It was followed by the treatment of aldicarb (2 kg *a. i.*/ha), disulfoton (1 kg *a. i.*/ha) and phorate (2 kg *a. i.*/ha). It is thus evident that the treatment of disulfoton even at the treatment dosage of 1 kg *a. i.*/ha was superior over phorate (2 kg *a. i.*/ha) treatment.

The results presented in Table 2 reveal that the treatment of malathion gave higher percentage reduction of aphid population than that of endosulfan, sprayed alone or on plants grown on treated soils. In case of malathion treatment given on crops grown on insecticide treated soil, the order of percentage reduction of aphid population at both 40 and 55 days interval was : aldicarb, phorate and disulfoton. The yield obtained from the treatment of aldicarb + malathion was significantly more than all the treatments, followed by aldicarb + endosulfan and disulfoton + malathion. The treatment of phorate + endosulfan was as good as malathion treatmnt alone. It is thus clear from the above that the yield of mustard can be increased considerably if the application of malathion is done on the crop grown on aldicarb treated soil.

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THREE NEW SPECIES OF APHIDS (HOMOPTERA: APHIDIDAE) FROM MANIPUR AND NAGALAND

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Three new species, *viz.*, *Dactynotus parasonchi*, *Hydronaphis colocasiae* and *Eutrichosiphum* (*Neoparatrichosiphum*) *litseae* are described in the present paper. A discussion on the status of the genus *Paratrichosiphum* has also been included.

INTRODUCTION

A systematic survey of the aphid fauna of Manipur and Nagaland has been undertaken since November 1975. During the course of this survey three new species have been collected which are described below. A discussion on the status of the genus *Paratrichosiphum* Takahashi has been incorporated. The genus *Hydronaphis* is being recorded here for the first time in India.

All the material are in the Entomology Laboratory, Department of Zoology, Calcutta University.

1. Dactynotus parasonchi, sp. nov.

Apterous viviparous female: Body elongate, about 2.97—3.11 mm long with 1.40—1.41 mm as maximum width. Head deep brown with diverging lateral frontal tubercles. Antennae broken from segment IV or segment V onwards, darker than the head with very base of segment III slightly paler, basal two segments scabrous on inner margin; segment III imbricated near base and on distal 0.50 portion, rest of the segment smooth, segment IV onwards with distinct imbrications; 21–23 round, small to large, protuberant, secondary rhinaria distributed irregularly on the basal 0.53—0.58 portion excepting the very base on segment III; flagellar hairs, short, stiff, thick with slightly spatulate to incrassate apices, longest hair on segment III about 0.75 × the basal diameter of the segment. Rostrum reaching hindcoxae; ultimate rostral segment nearly as long as the length of the second segment of hindtarsus, bearing 6–7 secondary hairs. Midthoracic furca with a short stalk. Dorsum of abdomen pale with a few hair-bearing sclerites posteriorly, dark post-siphuncular sclerite, a brown patch on each of 7th and 8th tergites; dorsal abdominal hairs long and stiff on raised sockets and with spatulate apices, these appear longer caudad; 7th abdominal tergite with 6 hairs and 8th with 4 hairs, longest hair on anterior tergites upto about 1.10 × basal diameter of the antennal segment III; hairs on 7th and 8th tergites are of equal length and longest hair on these tergites about 1.33 × the mentioned diameter. Siphunculi deep brown, but slightly paler apically, cylindrical, imbricated and reticulated with isodiametrical cells on about apical 0.25 portion, about 0.30—0.32 × the length of body and about 1.65—1.76 × the length of cauda which is pale, greatly elongated, without a basal constriction, with about 22 long and short hairs and with the shorter hairs being mostly towards the bases. Femora pale brown on basal 0.50 portion, rest

dark brown, smooth on margin excepting a few spinulose striae on upper surface near apices and with such striae on the under surface extending upto distal 0.50 portion, femoral hairs with acuminate to incrassate apices; tibiae dark brown at the knee and brown near the apices, rest pale brown smooth, with hairs similar to those on femora. Hindtibiae not swollen but with a number of pseudorhinaria like structures on basal 0.50 portion. F.T.C. 5.5.5.

Measurements of the holotype in mm : length of body 2.97, width 1.40; ultimate rostral segment 0.16; second segment of hindtarsus 0.17; siphunculus 0.95; cauda 0.54.

Holotype: Apterous viviparous ♀, INDIA : MANIPUR, 10.ii.1976, from *Sonchus arvensis* (Compositae), **Paratypes :** 1 apterous viviparous ♀ and many nymphs, collection data same as for the holotype.

This new species approaches very close to *Dactynotus sonchi* (L.) but differs in having the longest hair on each of the 7th and 8th abdominal tergites of similar length and pseudorhinaria like structure on the hind tibiae.

2. Eutrichosiphum (Neoparatrichosiphum) litseae, sp. nov.

Apterous viviparous female: Body pear shaped, about 1.55—1.80 mm long with about 0.90—1.05 mm as its maximum width. Head pale brown without any lateral frontal tubercles and with many long hairs with acuminate to slightly furcated apices. Antennae 6-segmented, pale except the basal 2 segments, the very apex of segment V and whole of segment VI which are darker and of these the basal segments concolourous with the head and the latter two portions brown, about 0.36—0.40 × the length of body; flagellum imbricated; processus terminalis about 0.79—0.81 × the base of segment VI (Fig. 1) and about 0.45—0.56 × the length of antennal segment III; long and short hairs occur intermingled and with acuminate apices. Rostrum reaches 1st abdominal segment ; segments 4+5 of rostrum about 2.30—2.50 × the length of hindtarsi and segment 4 about 4.75—6.20 × the length of segment 5 and bears 6 secondary hairs. Thoracic and abdominal tergites pale and smooth. Numerous long and short hairs occur on the dorsum of abdomen and these are with acuminate to furcated apices; longest hair on anterior tergites about 2.25 × the basal diameter of antennal segment III and shortest hair on such tergites about 0.35—0.50 × the mentioned diameter; tergite 7 with 7—8 hairs and of these 4 are appreciably longer, longest hair about 2.60 × the mentioned diameter; tergite 8 with 2 long, fine hairs which are about 1.80—2.80 × the mentioned diameter. Siphunculi pale, cigar shaped without any reticulation and with long and short hairs, the shorter ones being near the base, both long and short hairs usually with acuminate apices but seldom one or two hairs near base wih slightly furcated apices, about 0.15—0.16 × the length of body and about 4.50—5.50 × its maximum width, at base 1.50—1.80 ×, at apex 1.30—1.40 × the width at the middle of hindtibiae. Cauda helmet shaped with 6 hairs. Legs pale brown with the femora and tarsi slightly darker; femora with spinulose striae ventrally near the apices; tibiae smooth with 4 thick spiny hairs near apices, F.T.C. 7,7,7.

Measurements of the holotype in mm : Length of body 1.62, width 0.93, antenna 0.60; antennal segments III : IV : V : VI 0.15 : 0.07 : (0.08 : 0.10)+ 0.08; rostral segments (4+5) 0.23 (0.19+ 0.04); second segment of hindtarsus 0.10; siphunculus 0.26; width of siphunculus at base, at middle and at apex, 0.04, 0.07, 0.04.

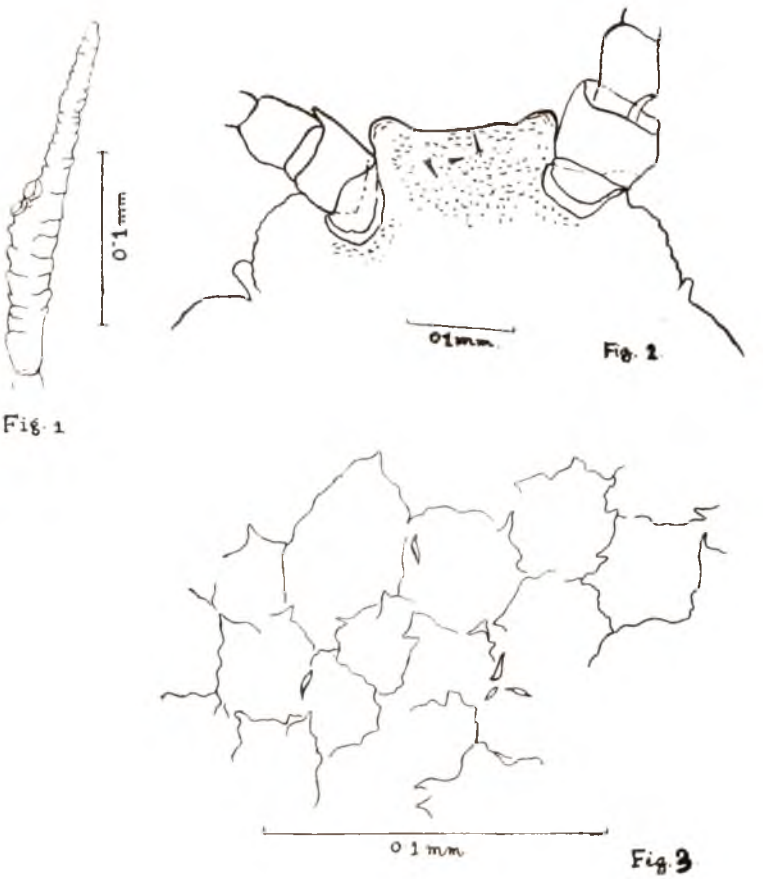

Fig. 1. *Eutrichosiphum* (*Neoparatrichosiphum*) *litseae*, *sp. nov.* : antennal segment VI.

Figs. 2–3. *Hydronaphis colocasiae, sp. nov.*: 2–head dorsal view; 3–pattern of reticulation on abdominal dorsum.

Holotype: Apterous viviparous ♀, INDIA : MANIPUR, 22.vi.1976, from *Litsea sebifera* (Lauraceae), **Paratypes:** 6 apterous viviparous ♀ ♀ collection data same as for the holotype.

According to Raychaudhuri (1956), this new species in having 6–segmented antennae and smooth abdominal dorsum should come under he genus *Paratrichosiphum* Takahashi and in that event it should be put under the subgenus *Neoparatrichosiphum* erected by Ghosh and Raychaudhuri (1962) because of the presence of few furcated hairs on the siphunculus. Another genus *Eutrichosiphum* Essig and Kuwana, closely allied to *Paratrichosiphum,* had been distinguished only by one character that is 5–segmented antennae in contrast to 6–segmented antennae in *Paratrichosiphum.* Recently Raychaudhuri and Chatterjee in a monograph "On the aphids of North-East India and Bhutan" (in press) considered *Paratrichosiphum* and *Neoparatrichosiphum* as subgenera of *Eutrichosiphum* because they believe that variation in the number of antennal segments should not be regarded as a criterion for generic separation. So following recent concept, this new species comes under the subgenus

Neoparatrichosiphum of the genus *Eutrichosiphum* and is distinct from all other species of the genus in having processus terminalis shorter than the base of the last segment.

3. Hydronaphis colocasiae, sp. nov.

Apterous viviparous female : Body pear shaped but shrunken. Head (Fig. 2) faintly brown, spinulose on both surfaces but the spinules are more dense anteriorly and not found on the posterior margin, with distinct lowly elevated, scabrous, diverging lateral frontal tubercles and indistinct median frontal prominence. Dorsal cephalic hairs long and fine, longest of these hairs as long as the basal diameter of segment III. Antennae about 1.60—1.78 mm long; basal two segments slightly darker than that of the head, smooth on upper surface and scabrous on the lower surface, segment I with 8 fine hairs and segment II with 7 such hairs; flagellum pale with the very apex of segment IV and the whole of segments V and VI darker; segment III faintly imbricated, these imbrications look like small indistinct spinules on the margin, rest of the flagellum gradually more distinctly imbricated apically; flagellar hairs rather sparse short with acuminate apices; a few of these hairs on segment III very short and thorny longest one on segment III about 0.41—0.50× basal diameter of segment III and the shortest thorny hair about 0.13× the mentioned diameter, segment III with a hardly discernible circular secondary rhinaria near base on the inner margin; processus terminalis about 3.8 to 4.5× the base of segment VI; primary rhinaria ciliated. Rostrum long, reaches past the hindcoxae; ultimate rostral segment with nearly parallel sides and blunt apex, about 1.50—1.60× second joint of hindtarsus, with 2 secondary hairs, midthoracic furca probably with jointed arms and without a stalk. Thoracic and abdominal tergites pale and with spinules which unite to form distinct polygonal reticulations (Fig. 3). Lateral abdominal tubercles absent. Dorsal abdominal hairs sparse, long and fine placed on strong sockets, longest hair on anterior abdominal tergites about 1.4× basal diameter of segment III; each of 7th and 8th abdominal tergites with 4 long fine hairs; longest of these hairs about as long as the similar hairs on anterior tergites. Siphunculi pale with the very apex dark, about 3.2—3.7× the cauda, subcylindrical with broad base and weakly 'S' shaped apex, strongly imbricated and with a flared apical flange. Cauda pale, shortly conical, blunt at apex with 6 hairs. Subgenital plate oval with long and fine hairs irregularly arranged. Femora pale, brown on basal 0.5 portion, rest darker with spinular striae apically on the ventral surface; femoral hairs mostly long and fine, a few thorny ones found apically. Tibiae pale brown with the very base and apex dark; tibial hairs stout and with acuminate apices. Tarsi pale brown and striate; first tarsal segments with 3 hairs.

Measurements of the holotype in mm : Antennae 1.71; antennal segments III: IV: V: VI 0.31: 0.31: 0.19: (0.13 + 0.52); u.r.s. 0.99; h.t.2 0.60, siphunculus 0.48; cauda 0.13.

Holotype : Apterous viviparous ♀, INDIA: NAGALAND, 6.i.1976 from *Colocasia* sp., **Paratypes:** 4 apterous viviparous ♀ ♀, collection data same as for the holotype.

The specimens collected have characters which possibly justify their inclusion in the genus *Hydronaphis* Shinji (Head spinulose on both surfaces, antennae with imperceptible secondary rhinaria; thoracic and abdominal tergites with spinules forming reticulations; body hairs long, stout with fine apices, siphunculi flared near the flange and short cauda). Following Miyazaki

(1971) this new species comes close to *impatiens* Shinji which has been redscribed by Takahashi (1965). But the new species differs from *impatiens* in having pale body, in the absence of antesiphuncular sclerite and longer ultimate rostral segment in comparison to h.t.2 besides other characters.

Acknowledgements:—The authors are thankful to the University Grants Commission, New Delhi for financing the project for working on the aphids of Manipur and Nagaland, the Head of the Department of Zoology, Calcutta University for laboratory facilities, the Education Directorate, Government of Manipur for providing accomodation at Manipur, the Director of Agriculture, Government of Nagaland for active co-operation during collection in Nagaland, to the Head of the Department of Botany, Calcutta University and to the Botanical Survey of India, Calcutta for identification of some of the plant material.

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TWO NEW SPECIES OF APHIDS (HOMOPTERA: APHIDIDAE) FROM SIKKIM, NORTH EAST INDIA

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Two new aphids *viz.*, *Akkaia sikkimensis*, sp. nov. infesting *Raphanus sativus* and *Macrosiphoniella sikkimartimisiae*, sp. nov. infesting *Artemisia* sp. collected from Sikkim, North East India are described.

Examination of a collection of aphids from Sikkim made during the period of a year has revealed two new species, which are described here.

Materials of these species are deposited in the Entomology Laboratory, Department of Zoology, University of Calcutta.

1. Akkaia sikkimensis, sp. nov.

Apterous viviparous female: Body elongate, pear shaped, 2.54—2.63 mm long with 1.27—1.37 mm as its maximum width near the middle of the abdomen. Head (Fig. 1) pale brown, rugose anteriorly and with small warts on the posterior margin, with a pair of inwardly directed thumb shaped projections from lateral frontal tubercles and these extend a little beyond the proximal 0.50 portion of antennal segment I and are warty with inner margins nearly parallel and outer margins somewhat concave and bear small hairs with slightly expanded apices; dorsal cephalic hairs short and club-shaped, longest of these about 0.40× basal diameter of antennal segment III. Antennae 6-segmented, about 0.40—0.44× the length of the body, nearly concolorous with the head excepting the basal two segments and processus terminalis which are slightly darker; hairs on flagellum sparse, minute with bluntish to slightly expanded apices, the longest hair on segment III slightly more than 0.20 × the basal diameter of the segment; segment I warty on inner margin and with a median round inwardly directed projection, with about 4 hairs; segment II longer than wide, warty on the inner margin and also with 4 hairs; inner margins of segments III, IV V and base of segment VI warty, outer margin of segment III and proximal 0.5 portion of segment IV smooth while the outer margin of rest of the segments distinctly imbricated; secondary rhinaria absent; primary rhinaria star-shaped; rostrum reaching mid-coxae; ultimate rostral segment blunt, as long as to slightly longer than second segment of hindtarsus and with a pair of secondary hairs. Abdominal tergum pale to pale brown, warty; 7th abdominal tergite with two small hair-bearing tubercles laterally and the tubercle on 8th tergite median and prominent; dorsal abdominal hairs minute, stumpy, sparse and somewhat barrel-shaped, but the two hairs on each of 7th and 8th tergites longer and with blunt apices, longest hair on 7th tergite nearly 0.5× the basal diameter of antennal segment III and that on 8th tergite slightly longer than the similar hair on the 7th tergite. Siphunculi (Fig. 2) weakly S-

Fig 1

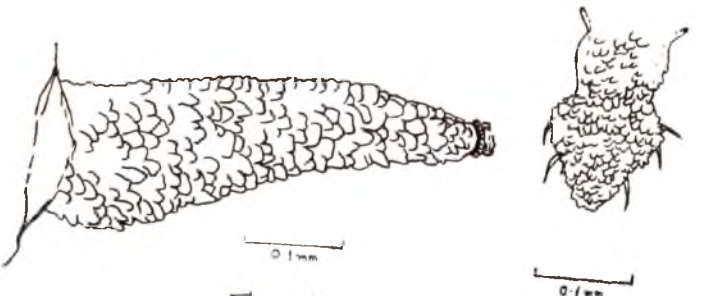

Fig -2

Fig.-3

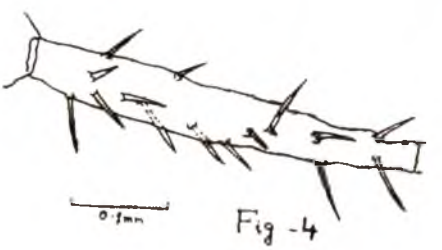

Fig -4

Fig. 1–3. *Akkaia sikkimensis*, sp. nov. apterous viviparous ♀ : 1—head; 2—siphunculus; 3–cauda.

Fig. 4. *Macrosiphoniella sikkimartemisiae*, sp. nov. apterous viviparous ♀, antennal segment III.

shaped, brown with the margins darker, warty (the warts on the margins look like small blunt denticles), abruptly narrowed just before the strongly developed flange, about 0.21—0.22× the length of the body and about 2.3—2.4× the length of cauda (Fig. 3) which is with a straight base and a heart-shaped apex bearing 9–11 fine hairs. Subanal plate triangular and extends almost up to the middle of cauda; subgenital plate strongly denticulated on posterolateral corners; 6th and 7th spiracles broader than other spiracles. Legs uniformly brown; femora distinctly warty on its outer margin and on ventral surface, at least, near the apices, inner margin smooth; femoral hairs like those on dorsum of the head, but longer, tibial hairs long and short, the longer ones on the inner margin and pear shaped, the shorter ones on the outer margins with subacute to bluntish apices. First tarsal chaetotaxy 4,4,2.

Measurements of the holotype in mm: Length of body 2.63, width 1.33; antenna 1.11, antennal segments III : IV : V : VI 0.42 : 0.19 : 0.12 : (0.09 + 0.13); u.r.s. 0.11; h.t. 2 0.11; siphunculus 0.57; cauda 0.24.

Holotype : Apterous viviparous ♀, INDIA : SIKKIM : Mangan, 8.xii.1975, from *Raphanus sativus,* coll. S. Dutta, **Paratype :** 2 apterous viviparous ♀ ♀ and few nymphs, collection data same as for the holotype.

Remark : This new species differs from all other species of the Genus *Akkaia* Takahashi chiefly in having first tarsal chaetotaxy 4,4,2.

2. Macrosiphoniella sikkimartimisae, sp.nov.

Apterous viviparous female : Body shrunken, head brown, smooth with well developed diverging lateral frontal tubercles and without any median frontal prominence; dorsal cephalic hairs long, stout with acuminate apices, longest one about 3.1—3.3× the basal diameter of antennal segment III. Antennae 6-segmented, shrunken; segments I and II concolorous with head, smooth; flagellum brown, segment III almost smooth, rest of the flagellum gradually more distinctly imbricated apicad; segment III with 4–5 small to medium sized circular protuberant secondary rhinaria distributed on basal half; flagellar hairs (Fig. 4) with rather bluntish to acuminate apices, longest one on segment III about 1.6—2.1× the basal diameter of the segment; primary rhinaria non-ciliated. Rostrum just reaching the hindcoxae; ultimate rostral segment about 1.0—1.21× hindtarsi 2, with 4 pairs of secondary hairs. Abdomen pale; dorsal abdominal hairs on sclerotic bases, long with acuminate apices, longest one on anterior tergites about 3.3—5.6× the basal diameter of the antennal segment III; 8th tergite with 8 hairs, longest hair on 7th and 8th tergites are nearly of equal length and about 4.5—5.7× the mentioned diameter. Siphunculi calf-shaped, dark, distinctly imbricated and reticulated on about distal 0.4 portion, without a distinct flange, slightly longer than cauda and with a distinct antesiphuncular sclerite. Cauda dark, elongated, slightly constricted near base, bears 10 long hairs, shorter than the width of the head across the outer margin of the eyes. Femora brown with the apex slightly darker, smooth; tibiae pale brown with bases and apices darker; tarsi brown. Femoral hairs long and fine, some of the hairs on the outer margin of tibiae long and fine while other hairs shorter and with acuminate apices. First tarsal chaetotaxy 3,3,3.

Measurements of the holotype in mm: Antenna distorted apically; antennal segments III : IV : V : VI : 0.47 : 0.36 : 0.33 (distorted); u.r.s. 0.15; siphunculus 0.29; cauda 0.28.

Holotype : Apterous viviparous ♀, INDIA: SIKKIM: Rangrang, 6.xii. 1975, from *Artemisia* sp., coll. S. Dutta. **Paratype :** two apterous viviparous ♀♀ and two nymphs, collection data same as for the holotype.

Remark : Following Miyazaki (1971) and Basu and Raychaudhuri (1976) this new species comes close to *Macrosiphoniella formosartemisiae* Takahashi but differs from the same in having more hairy body, longer flagellar and dorsal abdominal hairs, antennae and legs uniformly brown and lesser number of caudal hairs.

Acknowledgements:—The authors are thankful to Indian Council of Agricultural Research, New Delhi for financing the work on aphids of Sikkim. Bhutan and hilly areas of West Bengal, the Department of Agriculture, Government of Sikkim for collection facilities, the Head of the Department of Zoology, Calcutta University for laboratory facilities, Botanical Survey of India for identification of plant materials, Dr. M. R. Ghosh, Department of Entomology, Bidhan Chandra Krishi Viswavidyalaya, Kalyani and Sri P. Mandal and Sri. T. Sen of the Entomology Laboratory, Department of Zoology, Calcutta University for manifold help.

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TWO NEW SPECIES OF THE GENUS *EPICAUTA* REDTENBACHER (MELOIDAE : COLEOPTERA) FROM KULU VALLEY, INDIA

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(*Received 6 November 1976*)

Two new species viz., *Epicauta montanus* and *E. mandibularis* collected from Himachal Pradesh, India are described.

The genus *Epicauta* Redtenbacher is world wide in distribution except in the Australian Region. HAAG-RUTENBERG's (1880) work is the most valuable contribution on the world fauna of this group, but he placed the species under the genus *Lytta* Fabricius. Werner (1945) synonymized various species and arranged them in a number of groups. Kaszab (1952) made valuable contribution on the Oriental and Palaearctic species of this genus and placed them in fourteen systematic groups based on the colouration, pubescence, antenna and tibial spurs. He also gave a key to the species. Twenty one species are so far known from India, three-fourths of which are confined along the Himalayan belt. The present paper deals with the description of two new species from Katrain (Altitude 3200 m), Kulu Valley (Himachal Pradesh).

1. Epicauta montanus sp. nov. (Fig. 1–7)

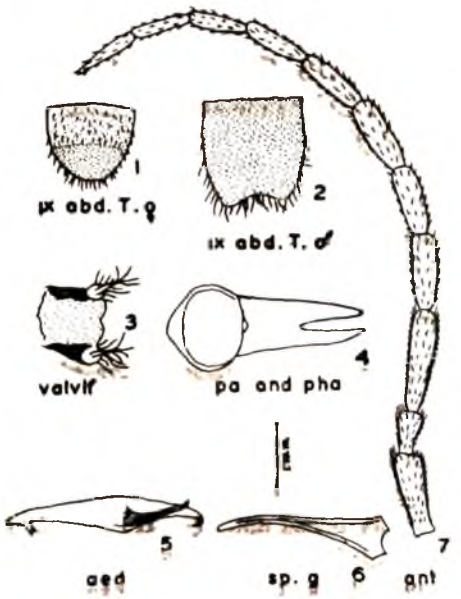
Male: Body large, black, cylindrical, finely pubescent; head dull red except black labrum, black clypeus anteriorly, reddish posteriorly with smooth punctured ovate spot at the base of each antenna, head covered with black hair laterally; antennae long, reaching almost the middle of body, segment I very broad apically, II the smallest, III the longest, more than twice as long as II, IV–V almost equal, cylindrical, VI–X cylindrical, progressively shortened, XI comparatively long and tapering; eyes fairly large and convex; pronotum thickly punctate with small black hair laterally; elytra elongate, narrowed at apex, finely pubescent; middle and hind legs with long, black hair, foretibial spur very long, tarsal claws long and tapering; ventral side black, fairly pubescent.

Genitalia : Abdominal tergum IX strongly sclerotized posteriorly, without hair, less sclerotized anteriorly, with hair, deeply invaginated and with curved hair on posterior margin ; parameres long, apices divergent, phallobase round and broad ; aedeagus with one small dorsal hook sharply curved at the tip and large curved ventral hook ; spiculum gastrale with short arms and shaft slightly bent at the apex.

Female: Similar to male except narrower antennae and emarginated last abdominal segment.

Genitalia : Abdominal tergum IX with uniform black hair along posterior margin, posteriorly more sclerotized, anteriorly less

[1] Part of the thesis of the author approved for the award of Ph. D. degree in 1975 of the Post-graduate School, Indian Agricultural Research Institute, New Delhi.



Figs. 1–7. *Epicauta montanus* sp. n.
(Explanation of abbreviations under Figs. 8–14)

sclerotized ; valvifer one-third narrowed proximally, distally broad, with a fairly long stylus bearing hair.

Length : 17–28 mm.

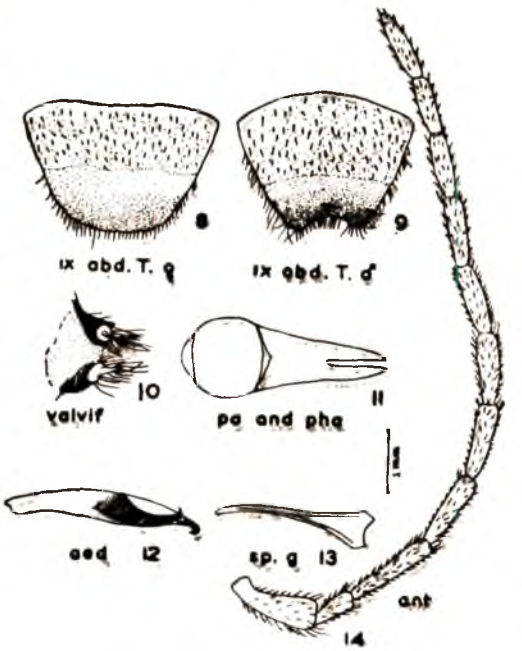
Holotype : ♂, INDIA : HIMACHAL PRADESH : Kulu Valley: Katrain, 18. x. 72, on chillies, R. K. Anand. **Paratypes:** 6♂♂, same data ; 4 ♀♀ same data. Both Holotype and Paratypes, deposited in National Pusa Collection (N. P. C.) I.A.R.I., New Delhi.

This species closely resembles *E. hirtipes* (Waterhouse) in colouration but can be distinguished from it by partly reddish clypeus long foretibial spur and aedeagus with long, sharply curved dorsal hook.

2. Epicauta mandibularis sp. nov. (Figs. 8–14)

Male : Body black, moderately large ; head orange-reddish, labrum and clypeus partly black, frons depressed, mandibles very well-developed, apically dentate ; antenna fairly long, filiform, segment I–III covered thickly with black hair, remaining segments with small fine hair, segment I broad apically, II the smallest and apically broad, III very long, almost three times as long as II, IV–VI almost equal, VII–X cylindrical, gradually narrow, XI tapering, pointed apically ; eyes small ; pronotum finely pubescent, densely punctate, slightly depressed medially ; elytra finely punctate, pubescent, widely divergent posteriorly ; legs with short hair, hindtibial spur reddish and long; ventral side with fine, short golden pubescence.

Genitalia: Abdominal tergum IX less sclerotized, slightly invaginated posteriorly, with long curved hair along the margins; parameres long, divergent, phallobase broad and almost rounded; aedeagus with one



Figs. 8–14. *Epicauta mondibularis* sp. n.
abd. T—abdominal tergum; aed—aedeagus; pa—paramere; pha—phallobase; sp. g.—spiculum gastrale; valvif—valvifer.

small sharply curved dorsal hook and one long ventral hook; spiculum gastrale with short arms, shaft long and rounded at the apex.

Female: Similar to male except that the antennae are more slender.

Genitalia: Abdominal tergum IX anteriorly membranous, posteriorly sclerotized with short hair; valvifer proximally one-third narrow and gradually increasing distally, stylus long, tapering and with few long hairs.

Length: 14–23 mm.

Holotype: ♂, INDIA: HIMACHAL PRADESH: Kulu Valley, Katrain,: 18. ix. 72 on soybean, R. K. Anand. **Paraytypes:** 7 ♂♂, same data; 4 ♀♀, same data. Both Holotype and Paratypes deposited in N. P. C., I.A.R.I., New Delhi.

The new species closely resembles *E. napalensis* (Hope) but can be distinguished from it by complete black colour of the body, well developed apically dentate mandibles, long third antennal segment, strongly sclerotized ninth abdominal tergum in male, large ventral aedeagal hook and short arm of spiculum gastrale.

Acknowledgements:—I thank Dr. N. C. Pant, Head of the Division of Entomology, I.A.R.I., New Delhi, for providing the necessary facilities and to Dr. (Miss) Swaraj Ghai, Systematic Entomologist for her help at various stages and critically going through the manuscript.

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NEW SPECIES BELONGING TO MELOLONTHINI (COLEOPTERA: SCARABAEIDAE: MELOLONTHINAE) FROM INDIA

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Three new species *viz.*, *Holotrichia freyi* **sp. nov.,** *Schizonycha aruficollis* sp. nov. **and** *Brahmina cupreus* **sp. nov. are described from India.**

1. Holotrichia freyi sp. nov. (Figs. 1, 3, 4)

Body oval, compact and convex, 16.0–20.0 mm long and 9.0–11.0 mm broad, dull, brown-black to brown-red; sternum closely covered with long silky hair.

Head strongly, densely and subrugosely punctate, clypeus with margin rounded and reflexed, very feebly excised in front; front less punctate anteriorly; vertex raised transversely. Antennae 10-segmented.

Fig. 1. *Holotrichia freyi* sp. nov.

Fig. 2. *Brahmina cupreus* sp. nov.

Pronotum moderately strongly and thinly punctate, a little closely anteriorly; lateral margins strongly rounded in middle and almost straight in front and behind, with all angles blunt and obtuse. Scutellum finely and a little closely punctate. Elytra finely and rather closely punctate except some irregular longitudinal areas. Foretibia strongly and bluntly tridentate; tarsi slender; claws strongly toothed.

Pygidium moderately strongly and closely punctate. Phallobase a little narrower anteriorly. Parameres strongly tapering and curved inwards posteriorly; each with its inner wall dorsally bearing a long arcuate, bisinuate pointed plates slightly cleft before apex. Aedeagus long, tubular, well sclerotized, with two apodemes posteriorly. Endophallus elongate, membranous, closely set with short distinct spines and with a long highly sclerotised spatula at apex. Coxites well developed and consolidated. Bursa copulatrix exceptionally long, tubular and membranous. Spermatheca well developed, slightly curved, conical apically; with spermathecal duct very long, convoluted near spermatheca, spermathecal gland also very long.

Holotype ♀, **Allotype** ♂, **Paratypes** 2♂♂, 2♀♀, INDIA : HARYANA : Kurukshetra, night collection from light sources, I. C. Mittal. Material in Department of Zoology, B.N.C. University, Kurukshetra.

The species has been confirmed as new by Dr. G. Frey, and hence it has been named after him.

2. Schizonycha aruficollis sp. nov.

Body oblong, 10.00 mm long and 5.0 mm broad; reddish yellow, with head and pronotum more dark; lower surface covered very thinly with fine setae.

Head with two transverse carinae, front one strong, sharp and arcuate, hind one week and straight; clypeus narrowing in front, straight on sides, reflexed in front, sinuate in middle, almost smooth and shining; front rather coarsely and closely punctate-granulate.

Pronotum sparsely, strongly and coarsely punctate, with fine granulation in anterior part; lateral margins strongly and roundedly angulate on sides, all angles obtuse. Scutellum punctate in anterior half only. Elytra strongly, evenly and moderately closely punctate. Foretibia strongly tridentate, hindtibia with smaller spur almost straight and longer curved; claws cleft.

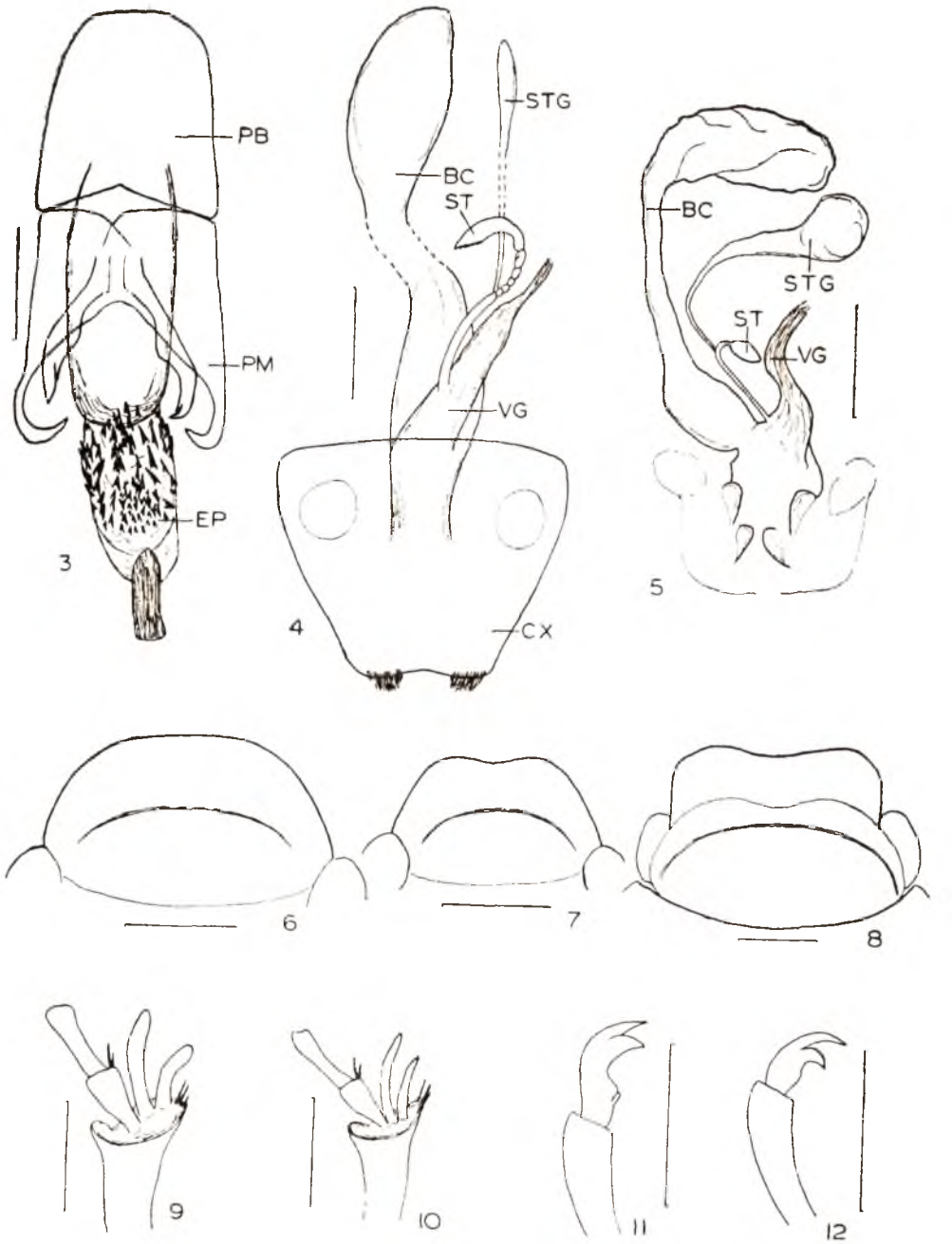
Pygidium feebly and sparsely punctate, slightly incised on sides near apex.

Holotype ♀, INDIA: HARYANA: Kurukshetra, night collection from light sources, I. C. Mittal. Material in the Department of Zoology, B.N.C. University, Kurukshetra.

The species differs from *S. ruficollis* (F) ♀ mainly in clypeus being sinuate in front and straight on sides (Figs. 6, 7), in punctation of head, pronotum and scutellum and in hindtibial spurs being slender and the smaller one almost straight (Figs. 9, 10). The species is also smaller in size and less abundant. This is confirmed as a new species by Dr. G. Frey.

3. Brahmina cupreus sp. nov. (Figs. 2,5,8)

Body oblong-ovate, convex, 16.0 mm long and 7.5 mm broad, coppery-red with strong metallic lustre; covered rather thinly with very long setae on head, pronotum, scutellum, legs and penultimate abdominal segment, very thickly on sternum, rather thickly with short setae on abdomen, and very sparsely on elytra.



Figs. 3–4. *Holotrichia freyi*, genitalia: 3, male; 4, female.
Fig. 5. *Brahmina cupreus*, female genitalia.
Figs. 6–7. anterior part of head: 6, *Schizonycha ruficollis* (F); 7, *S. aruficollis* sp. nov.
Fig. 8. *B. cupreus*, head.
Figs. 9–10. last part of left hindtibia: 9, *S. ruficollis* (F); 10, *S. aruficollis*.
Figs. 11–12. left hindclaw: 11, *B. cribricollis* (Redt.); 12, *B. cupreus*. PB—phallobase; PM—parameres; EP—endophallus; BC—bursa copulatrix; ST—spermatheca; STG—spermathecal gland; VG—vagina; CX—coxite. The line of magnification in all the figures denotes 1.0 mm.

Head coarsely and densely punctate-granulate; clypeus moderately and broadly excised in middle, margin strongly reflexed; fronto-clypeal suture trisinuate; frontal area with a curved, prominent but blunt carina from eye to eye. Eyes not prominent above.

Pronotum very strongly and unevenly punctate, densely anteriorly, with extreme basal margin smooth except in middle; lateral margins strongly and roundedly angulate behind middle, anterior angles sharp and obtuse, posterior angles blunt and very obtuse. Scutellum strongly and closely punctate except extreme lateral margins. Elytra moderately strongly and closely punctate, without distinct costae; lateral margins fringed with very long and fine bristles, and apical angles rounded. Metasternum prominent in middle longitudinally in anterior part only. Legs rather long and slender; foretibia strongly tridentate; claws very strongly cleft (Figs. 11, 12).

Abdominal segments setose and punctate in middle only except last one with long setae on posterior border. Posterior margin of propygidium closely set with short setae. Pygidium densely and coarsely punctate with setigerous punctures. Coxites very less developed. Bursa copulatrix very long and tubular. Spermatheca more or less oval, with spermathecal duct long and opening near junction of vagina with bursa copulatrix.

Holotype ♀, INDIA: U.P.: Dehradun from vegetation, I. C. Mittal. Material in the Department of Zoology, B. N. C. University, Kurukshetra.

The species differs from other allied species mainly in the presence of deep coppery metallic colour, and very long hair in anterior part of the body.

Acknowledgement:—The authors are thankful to Dr. G. Frey of Museum G. Frey, West Germany and Dr. R. B. Madge of Commonwealth Institute of Entomology, London for helping in the identifications. Thanks are also due to the Head of the Department of Zoology for providing necessary facilities, and the University Grants Commission, New Delhi for the award of a research fellowship to the first author.

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A NEW SPECIES OF *ALEUROTUBERCULATUS* TAKAHASHI AND REDESCRIPTION OF *ALEUROTUBERCULATUS MINUTUS* (SINGH) (ALEYRODIDAE, HEMIPTERA)

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A new aleyrodid (Aleyrodidae, Hemiptera) infesting *Neolitsea* sp. has been named as *Aleurotuberculatus kolliensis* and described. The aleyrodid *A. minutus* (Singh) has been redescribed. A key to Indian species of *Aleurotuberculatus* has been furnished.

The genus *Aleurotuberculatus* Takahashi is represented in India by four species. An aleyrodid species collected from *Neolitsea* sp. was found distinct from the known species of *Aleurotuberculatus* which is described in detail. In addition a revised detailed description of the aleyrodid *A. minutus* (Singh) has been rendered as the original description was found defective. A workable key to the Indian species of *Aleurotuberculatus* is given.

1. Aleurotuberculatus kolliensis sp. nov.

(Figs. 1—4)

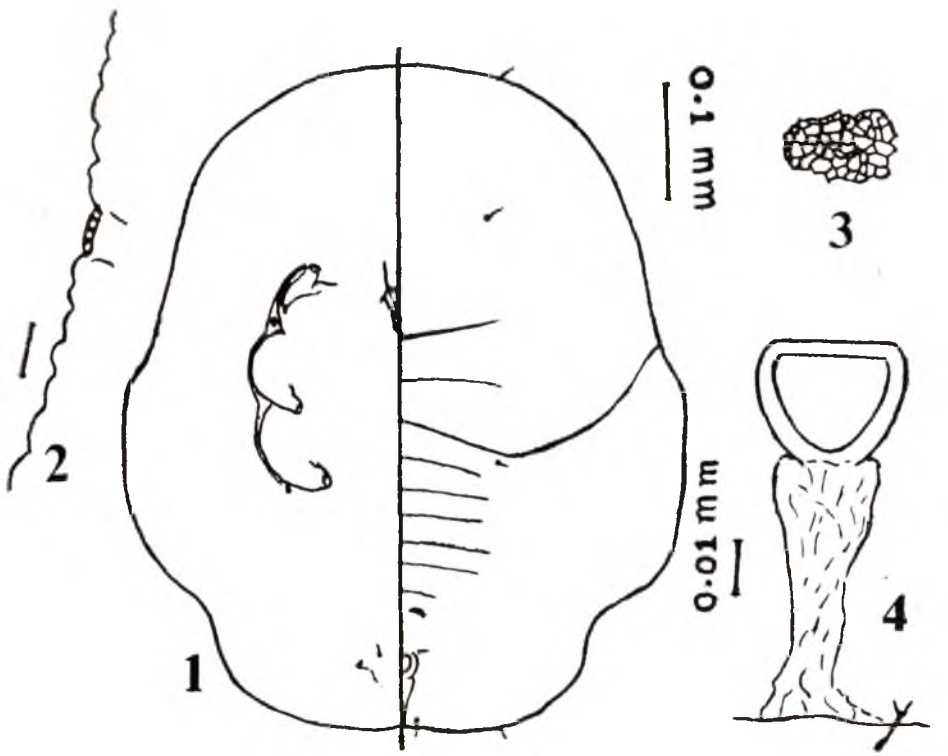
Pupal case: White without any waxy secretion, flat and thin. Length 0.603 to 0.689 mm, width at the broadest point 0.506 to 0.603 mm. Found scattered singly on the under surface of leaves.

Margin: Irregularly crenulate, about 30 rounded teeth in 0.1 mm. Broadest at the basal part of the abdomen but distinctly constricted at the posterior part and less so across the thoracic region a little behind the thoracic tracheal pore end; slightly indented at hindend. Thoracic tracheal pore end faintly indicated by sclerotized margin. Anterior and posterior marginal setae evident, respectively 14μ and 11.6–23.3μ long.

Dorsal surface: Dorsum faintly tessellated. Longitudinal moulting suture nearly reaching the margin; transverse moulting suture faint, extending forwards on the lateral part reaching the margin at the level of mesothorax. Abdominal segments distinct on the median area, pockets evident. Submarginal area not differentiated. Usual three pairs of setae evident—a pair on cephalic region, minute; a pair on basal abdominal segment, 9.3μ long; a pair on either side of vasiform orifice, minute. Abdomen somewhat shorter than cephalothorax. Thoracic tracheal furrow not evident. Caudal tracheal furrow distinct, faintly sculptured, 51.3–65.3μ long, 21.0–23.3μ wide at base and 7μ at posterior margin.

Vasiform orifice round, straight cephalad, 23.3–28.0μ long, 30.3μ wide, a little notched at the hindend. Operculum occupying most of orifice, rounded, 18.6 21.0μ long, 18.6–23.3μ wide concealing the lingula.

Ventral surface: Thoracic and caudal tracheal folds faintly discernible. Setae at base of rostrum and legs wanting. Prothoracic and abdominal spiracles evident. Antenna normal, short, not extending beyond



Figs. 1–4. *Aleurotuberculatus kolliensis* sp. nov.
1–Pupal case showing ventral and dorsal surface; 2–margin of case; 3–tassellation; 4–vasiform orifice.

the base of foreleg. Ventral abdominal setae 4.6μ long, 30.3–39.6μ apart.

Host: *Neolitsea* sp. (Lauraceae)

Material examined : **Holotype** : one pupal case on slide, INDIA: TAMIL NADU: Salem Dt. : Kolli Hills, *Neolitsea* sp., 20. iii. 1972, B. V. David, in author's collection. **Paratypes**: two pupal cases on a slide bearing the same data, deposited in the national collection of the Zoological Survey of India, Calcutta.

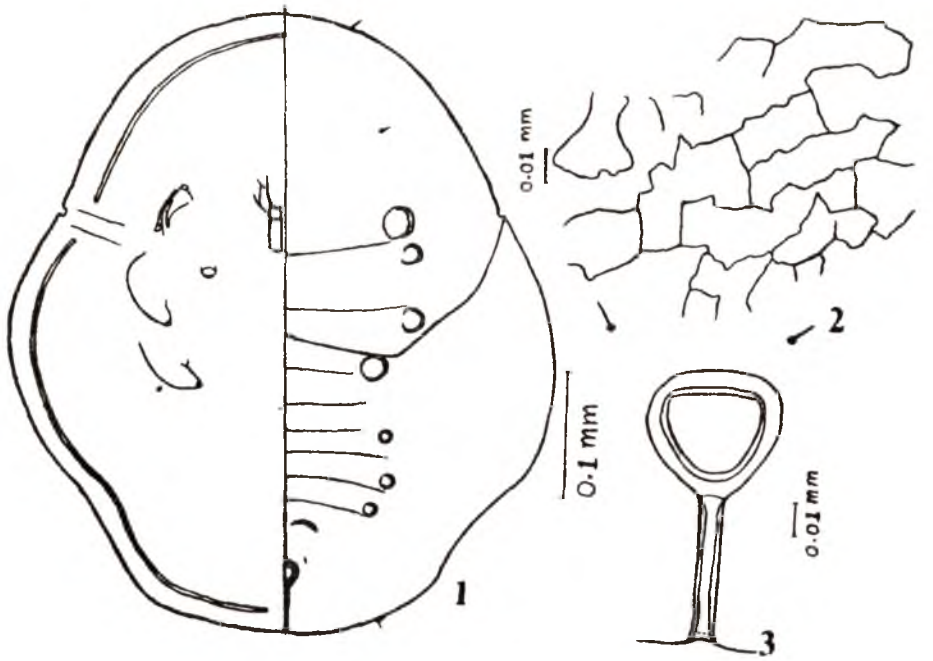
This species closely resembles *A. trachelospermi* Takahashi but differs in being smaller in size, not indented at the anterior margin of case, tassellated dorsum with transverse suture extending to margin and in the structural details of the vasiform orifice and the thoracic tracheal pore end.

2. Aleurotuberculatus minutus (Singh), 1931 (Figs. 1—3)

Dialeurodes minuta Singh, 1931, *Mem. Dept. Agric., India, Ent. Ser.* 12 (1) : 42.
Aleurotuberculatus minutus (Singh), Takahashi, 1934, *Rept. Dept. Agric. Formosa*, 63: 50; 1938, *Kontyu*, 12(2) : 73.

Since the first description of the species in 1931 by Singh from *Ixora coccinea* at Pusa (Bihar) no detailed information is available except for its inclusion under the genus *Aleurotuberculatus* by Takahashi. A redescription of the species is provided here with suitable illustrations.

Pupa case: White without any waxy secretion, wider at basal abdominal segment



Figs. 1–3. *Aleurotuberculatus minutus* (Singh)
1–Pupal case showing ventral and dorsal surface; 2–tassellation; 3–vasiform orifice.

and narrowed anteriorly and posteriorly. Length 0.554–0.568 mm; width 0.469–0.497 mm. Occurs in small numbers on the under surface of leaves and in view of its minute size it is quite often overlooked.

Margin: Weakly crenulate; paired anterior and posterior marginal setae small, 5–7μ long. Thoracic and caudal tracheal endings are acute indentations on margin.

Dorsal surface: Two pairs of dorsal setae—a pair on cephalic region, 9μ long; setae on basal abdominal segment absent; caudal setae not discernible. Dorsal surface with a marked tassellation all over; dorsal disc not separated from submargin by a linear marking. Transverse moulting suture runs to the posterior up to the subdorsum and then bends to the anterior sharply reaching the margin posterior to the thoracic tracheal indentation. Thoracic tracheal furrows wanting. Seventh abdominal segment is not shortened medially, as long as the sixth; pockets distinct, not contiguous. Three pairs of rounded tubercles on thorax and a pair on each of basal and fourth to sixth abdominal segments evident.

Vasiform orifice subcordate, wider than long with thickly chitinized edges, 30μ wide and 23μ long; operculum similarly shaped, 23μ wide, 16μ long, entirely filling the orifice obscuring the lingula. Caudal tracheal furrow distinct, 31μ long from posterior end of orifice.

Ventral surface: Ventral abdominal setae minute, 23μ apart, prothoracic and abdominal spiracles evident. Setae at base of legs and rostrum wanting; adhesive sacs seen. Antenna normal not extending beyond base of foreleg. Thoracic tracheal fold weakly indicated; caudal tracheal fold not discernible. Submargin with a linear marking running all round but broken in the region

of the thoracic and caudal tracheal fold areas. Singh had erroneously shown this line as found on dorsal surface separating the submargin from the dorsum.

Material examined: Fourteen pupal cases mounted, INDIA: TAMIL NADU: Madras, on *Ixora coccinea*, 11.ii.1972, B. V. David.

KEY TO INDIAN SPECIES OF *ALEUROTUBERCULATUS*

1. Pupal case jet black; submargin with radial striations..... .....*murrayae* (Singh)
— Pupal case white; submargin without radial striations.....2
2. Dorsum tassellated.....3
— Dorsum without tassellation 4
3. Dorsum with three pairs of tubercles on thoracic region and four pairs on basal and fourth to sixth abdominal segments; basal abdominal setae absent.....*minutus* (Singh)
— Dorsum without tubercles; basal abdominal setae present.....:**kolliensis** sp. nov.
4. Dorsum with crescent and arrow-head shaped granulations; cephalothorax with distinct anchor-shaped tubercles; abdominal segments medially pigmented and tuberculate. .....*psidii* (Singh)
— Dorsum with sparse granules sublaterally; cephalothorax with 2 pairs of rounded tubercles; on abdominal segments I and II and rarely on III medially a tubercle evident. .....*hexcantha* (Singh)

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ON A NEW SPECIES OF *ARRHENOTHRIPS* HOOD (THYSANOPTERA : PHLAEOTHRIPIDAE) FROM INDIA, WITH A KEY TO INDIAN SPECIES

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Arrhenothrips longisetis **sp. nov. is described from Darjeeling District, West Bengal and a key to the four Indian sepcies of the genus provided.**

Seven species of the genus *Arrhenothrips* Hood *viz. ramakrishnae* Hood (1919), *dhumrapaksha* Ramakrishna (1928) and *acuminatus* Ananthakrishnan (1969) from Southern India; *pacificus* Bianchi (1952) from New Caledonia in the South Pacific Ocean; *marieps* Faure (1954) from Transvaal, South Africa; *pauliani* Faure (1961) from Madagascar and *lewisi* (Bagnall, 1921) are so far known. The new species described below, forms the first record of the genus from North Eastern India.

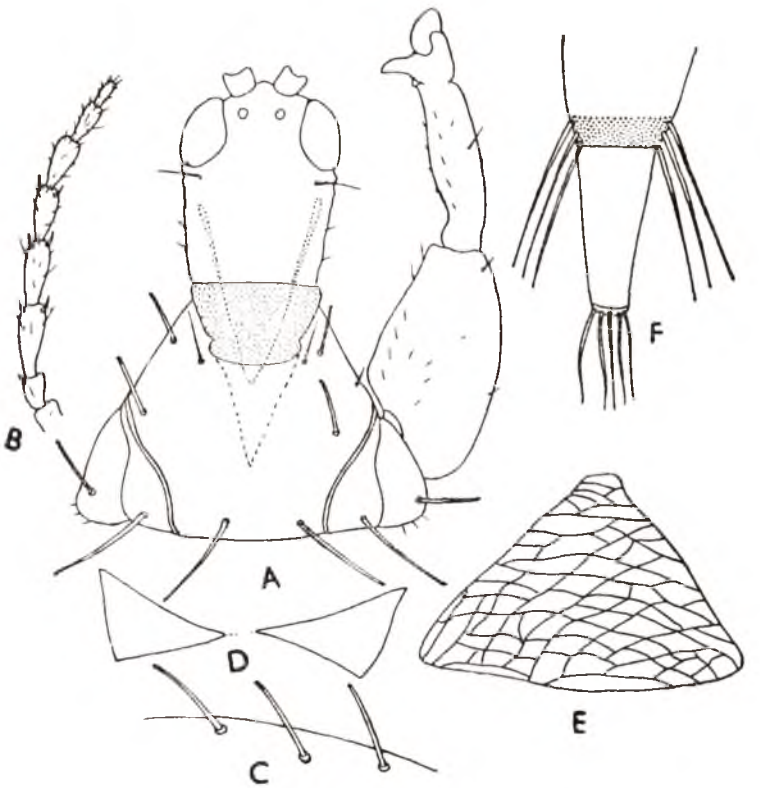
Arrhenothrips longisetis sp. nov.

Female (*Macropterous*) : General body colour brown, head and apex of abdomen dark, tube blackish brown except the tip; all femora, mid- and hindtibiae, mid- and hindtarsi, brown; foretibiae yellow with brownish tinge; foretarsi yellow; eyes pink; antennal segments I and VIII brown; II brown, dark in the basal half and paler distally; III–VII yellow; wings pale grey infumate; fringe cilia brown. All setae dark brown and blunt.

Head about 1.5 times longer than wide, 340[1]–360 long, 248–252 wide across eyes 240–244 across cheeks and 220–232 across base, sides almost parallel, cheeks finely crenulate with 4–6 small spines, surface strongly striate. Eyes little bulged and slightly extended ventrally, 112–128 long, 68–72 wide, all ocelli 24–28 wide, median ocellus placed 20 from the paired ones and the latter placed 40–44 apart. Postoculars blunt, 52–60 long, placed 28–36 below posterior margin of eyes. Antennal segments 3–7 pedicellate, length (width):—I: 52–64 (40–44); II: 64–72 (36–40); III: 112–120 (40–44); IV: 96–104 (48); V: 88–92 (32–36); VI : 80 (28–32); VII : 68–72 (24–28); VIII : 40–44 (16); sense cones 32–40 long. Mouthcone pointed, reaching about middle of prosternum, 200–216 long, 212–220 wide at base, 32–40 at apex. Maxillary stylets retracted into middle of head, "V" shaped, maxillary bridge absent.

Prothorax, 360–400 long, 240–260 wide at anterior margin, 440–460 wide at posterior margin. Anteroangulars slightly knobbed, 64–76 long; anteromarginals slightly knobbed 60–68 long; midlaterals slightly knobbed incurved 88–100 long; posteroangulars blunt, incurved 148–160 long; epimerals slightly knobbed, incurved 120–132 long, with a minute accessory seta; posteromarginals 2 pairs inconspicuous. Epimeral suture complete. Forefemora 192–208 wide, foretarsal tooth curved downwards 60 long.

[1] All measurements are in micra, unless otherwise mentioned.



Arrhenothrips longisetis sp. nov. A—head and prothroax; B—antenna; C—basal wing bristles; D—mesopraesternum; E—pelta; F—segment IX of abdomen and tube.

Pterothorax 600–640 long, 580–676 wide across mesothorax and 600–720 across metathorax. Metanotal setae 44–48 long. Forewings narrow, fringe cilia inserted below the costal margin 1.8—1.86 mm long, 72–92 wide, basal wing bristles slightly knobbed 80–84; 84–88 and 80–92 long respectively with 18–26 double fringes. Mesopraesternum (Fig. D) degenerate at middle.

Abdomen 540–580 wide at base; 440–520 at middle; 280–300 across segment VIII; 200–220 across segment IX. Pelta as in Fig. E apparently pyramid shaped. B_1, B_2 and B_3 of segment IX pointed 360–420; 340–360 and 360–400 long respectively. Tube 280–320 long; anal setae 280 long. Total body length : 3.7–4.00 mm.

Material:– Holotype ♀ (Z. S. I. Reg. No. 353/H12) and **paratypes** 6 ♀ ♀ (Z. S. I. Reg. No. 354–359/H12) on flower of an unidentified plant, INDIA: WEST BENGAL: Darjeeling District, Chunabati Forest Rest House, 17.ii.1974 (H. K. Bhowmik and party coll.).

The present species is closely allied to *acuminatus* Ananthakrishnan and can easily be distinguished by the 'V'-shaped maxillary stylets, well developed anteroangular, anteromarginal and midlateral pronotal setae as well as basal wing setae and narrower wings with larger number of double fringes.

KEY TO THE INDIAN SPECIES OF *ARRHENOTHRIPS* HOOD

1. Wings clear.
   Anteromarginals (21–29) very much shorter than anteroangulars (61–64). Postoculars and all prothoracic setae dilated at tip. Metanotal setae well developed. Forewings with 13–15 double fringes..... .....*ramakrishnae* Hood
   Wings never clear, from pale grey to cloudy....2
2. Postoculars longer than eyes.
   Anteromarginals (40–60) sub-equal to a little longer than anteroangulars (36–70). Postoculars and all prothoracic setae dilated at tip. Metanotal setae short. Forewings with 9–10 double fringes..... ....*dhumrapaksha* Ramakrishna
   Postoculars shorter than eyes.....3
3. Anteroangulars (8–13), anteromarginals (13–20) and midlaterals (10–13), very much reduced, shorter than postoculars (30–39). Maxillary stylets strongly approaching at the middle. Forewings with 8–10 double fringes and with very short basal wing bristles (23–39; 26–39; 29–52) ....*acuminatus* Ananthakrishnan
   Anteroangulars (64–76), anteromarginals 60–68), midlaterals (88–100) well developed; longer than postoculars (52–60). Maxillary stylets 'V' like not approaching. Forewings with 18–26 double fringes and with well developed basal wing bristles (80–84; 84–88; 88–92).....**longisetis** sp. nov.

Acknowledgements:—I express my thanks to the Joint Director-in-Charge, Zoological Survey of India, Calcutta for providing necessary facilities for work and thanks are also due to Shri K. S. Pradhan, Superintending Zoologist, Dr. O. B. Chhotani, Superintending Zoologist, Shri K. Rai, Zoologist and Dr. N. Muraleedharan, Asistant Zoologist, for help and encouragement. I am indebted to Prof. T. N. Ananthakrishnan, Entomology Research Unit, Loyola College, Madras, for kindly confirming the identification of the new species, going through the manuscript and offering valuable suggestions.

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DESCRIPTION OF TWO NEW SPECIES OF JUMPING-SPIDERS OF THE GENUS *PHIDIPPUS* (FAMILY: SALTICIDAE) FROM INDIA

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(*Received 6 November 1976*)

Two new species of jumping spiders, *viz.*, *Phidippus bengalensis* and *Phidippus khandalaensis* are described.

The spiders of the family Salticidae (Jumping-spiders) play an important role in the biological control of insect pests in nature. But unfortunately there has been very little work on the systematics of this interesting group of spiders in our country. This includes the work of Dyal (1935), Tikader (1965, 1967, 1973, 1974) and Sadana and Kaur (1974). While studying the jumping spiders in the collection of Zoological Survey of India, Poona, I came across two new species of spiders of the genus *Phidippus* which are described here.

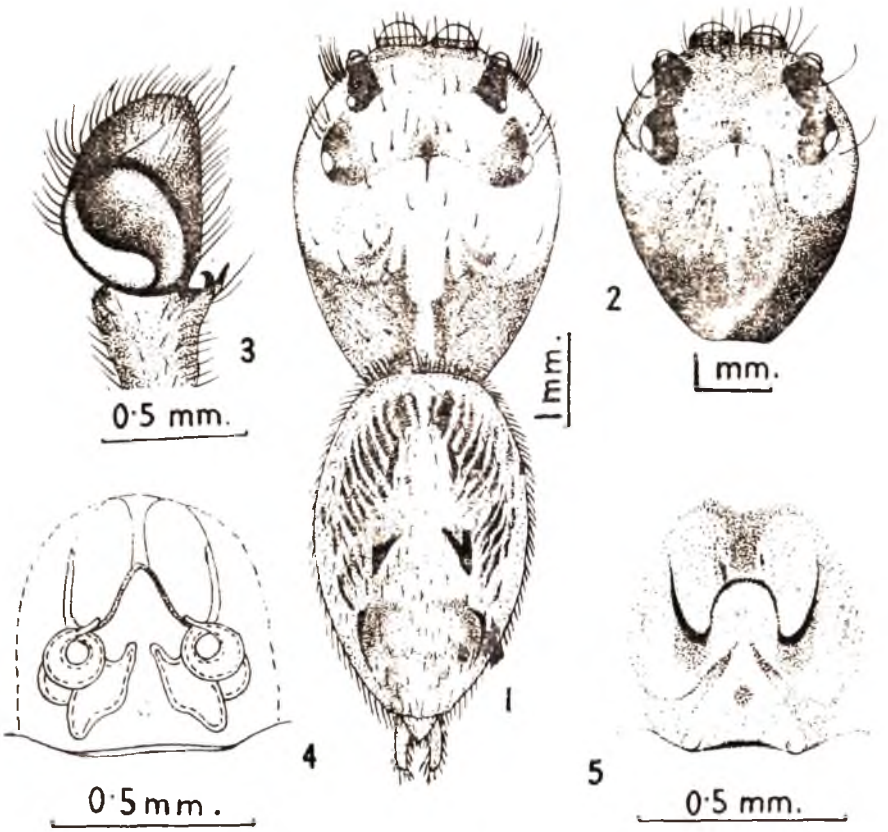
All type specimens will be deposited in due course in the National Collection, Zoological Survey of India, Calcutta.

1. Phidippus bengalensis sp. nov.

General : Cephalothorax, legs and adbomen light brown in female but male cephalothorax, legs brownish red and abdomen deep brown. Total length in female 8.00 mm. Carapace 4.00 mm long, 3.00 mm wide; abdomen 4.00 mm long, 2.50 mm wide.

Cephalothorax : Longer than wide, high in front, posterior and lateral sides sloping. Cephalic region flat, clothed with fine and some long hairs. In female, outer sides of lateral eyes provided with tuft of conspicuous long black hairs, as in Fig. 1. Anterior median and lateral eyes milk-white and other eyes pearly white. Anterior row of eyes recurved. Bases of all eyes except anterior median provided with conspicuous black patch. Anterior lateral eyes and posterior eyes nearly same size; second pair of eyes very small and situated near the anterior lateral eyes than the posterior eyes. Middle of cephalothorax provided with a small deep fovea. Chelicera wih one moderate tooth on inner margin and two small teeth on outer margin. Sternum nearly oval, longer than wide, narrowing in front. Legs clothed with hairs and spines, I and II more robust than III and IV. Tibiae and metatarsi I and II provided with three and two pairs of ventral spines. Male palp as in Fig. 3.

Abdomen : Longer than wide and pointed behind, clothed with hairs. Anterior lateral half of abdomen provided with deep brown patches. Middle of abdomen provided with a pair of sigilla which are encircled by a V-shaped black or brown marking as in Fig. 1. Ventral brown patch, extending from epigastric fold to the base of spinnerets. Epigyne and internal genitalia as in Figs. 4 and 5.



Figs. 1–5. *Phidippus bengalensis* sp. nov. 1—Dorsal view of female, legs omitted; 2—Cephalothorax of male, legs omitted; 3—Left male palp; 4—Internal genitalia; 5—Epigyne.

Holotype ♀, **paratype** ♀ and **allotype** ♂ in spirit. INDIA : WEST BENGAL : Howarah : Sibpur, Botanical garden, B. K. Tikader, 3.ii.1969. This species resembles *Phidippus indicus* Tikader but it is separated as follows: (i) Abdomen anterior lateral side provided with deep brown patch and middle with a pair of sigilla which encircled by a V-shaped black marking but in *P. indicus* abdomen dorsally decorated with some light patch. (ii) Male palp and female epigyne and internal genitalia also structurally different.

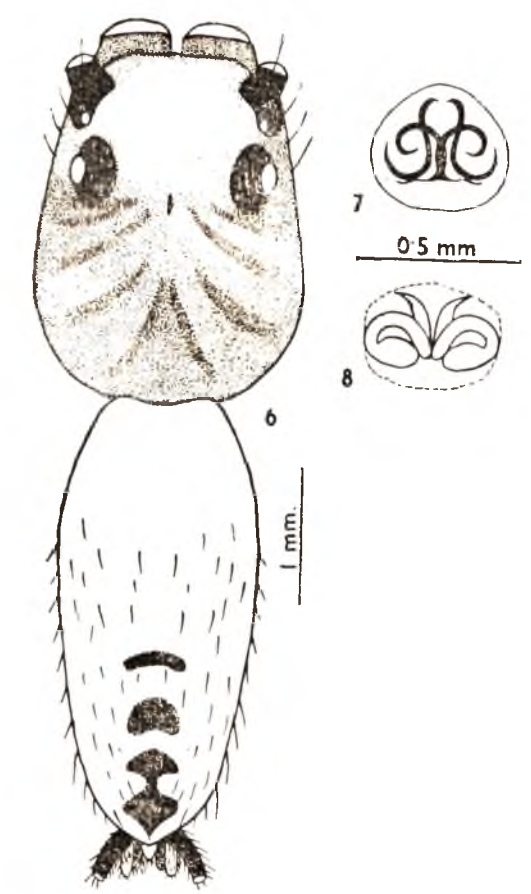
2. Phidippus khandalaensis sp.nov.

General : Cephalothorax, legs and abdomen pale orange colour. Total length 5.80 mm. Carapace 2.50 mm long, 2.00 mm wide; abdomen 3.30 mm long, 1.50 mm wide.

Cephalothorax : Longer than wide, high in front, posterior and lateral sides sloping. Cephalic region flat, clothed with fine hairs, outer sides of lateral eyes provided with few conspicuous long hairs. Anterior eyes pale and posterior eyes dark in colour. Anterior

row recurved, bases of all eyes except anterior median, provided with a black patch. Anterior lateral eyes slightly larger than the posterior lateral eyes, second pair of eyes very small and situated near the anterior lateral eyes than the posterior eyes. Middle of cephalothorax provided with a small deep fovea. Sternum broad and nearly heart-shaped pointed behind. Legs I and II more robust than III and IV. Tibiae and metatarsi I and II provided with three and two pairs of ventral spines.

Abdomen : Longer than wide and pointed behind, clothed with fine and some long hairs. Dorsally at the posterior end provided with three conspicuous black spots as in Fig. 6. Posterior spinnerets conspicuously black. Ventral side uniform pale. Epigyne and internal genitalia as in Figs. 7 and 8.



Figs. 6–8. *Phidippus khandalaensis* sp. nov. 6—Dorsal view of female, legs omitted; 7—Epigyne; 8—Internal genitalia.

Holotype ♀, in spirit. INDIA : MAHARASHTRA : Poona Dt., Khandala Rest House, Khandala Ghat, B. K. Tikader 4.xi. 1963.

This species resembles *Phidippus pateli* Tikader but it is separated as follows : (i) Dorsally at the posterior end of abdomen provided with three conspicuous black spots, but in *P. pateli* abdomen dorsally provided with a conspicuous V–shaped longitudinal deep brown band. (ii) Outer sides of lateral eyes provided with few conspicuous long hairs but in *P. pateli* the outer sides of lateral eyes provided with tuft of conspicuous long black hairs. (iii) Epigyne and internal genitalia also structurally different.

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BRIEF COMMUNICATIONS

NEW RECORD OF SOME TYPHLOCYBINES (HOMOPTERA, CICADELLIDAE, TYPHLOCYBINAE) FROM INDIA

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(*Received 6 November 1976*)

Six species of typhlocybines, *viz.*, *Empoasca albizziae* **Mahmood, Ahmed & Aslam,** *Erythroneura rhamnicola* **(Horvath),** *Eupteryx kaghanensis* **Ahmed,** *Helionidia karachiensis* **Ahmed & Khokhar,** *Typhlocyba longicephala* **Ahmed and** *Zyginidia pakistanica* **(Ahmed) are recorded for the first time from India.**

Leaf-hoppers from different kinds of vegetation were collected from north-western parts of India during 1966-75. The collection revealed the presence of six species of typhlocybines cited below, which appear to be recorded for the first time from India which are given below:

1. Empoasca albizziae Mahmood, Ahmed & Aslam

Empoasca albizziae described from Bangladesh and Pakistan by Mahmood *et al.* (1969) was noted as a serious pest of *Albizzia lebbeck* (Linn.) Benth and *A. procera* Benth. During the present surveys, this species was collected from *Albizzia lebbeck* at Ludhiana (Punjab).

Material : 3 ♂♂ and 2 ♀♀, from INDIA : PUNJAB : Ludhiana, lebbeck-tree, 16. v. 1967, A.S. Sohi.

2. Erythroneura rhamnicola (Horvath)

This species was reported from Pakistan by Ahmed (1970 a). During the present surveys, it was recorded from apricot, *Artemisia scoparia* and maize at Kulu and Solan (Himachal Pradesh).

Material : INDIA : HIMACHAL PRADESH: KULU, 1 ♂, from maize, x. 1972. G. S. Sandhu; 2♂♂ and 1 ♀, from *Artemisia scoparia*, 16. v. 1975, A. S. Sohi.

1 ♀, from apriot, Solan, 27. v. 1975, A. S. Sohi.

3. Eupteryx kaghanensis Ahmed

Ahmed (1969 b) described *Eupteryx kaghanensis* from Pakistan. This species has now been collected from peppermint (*Mentha piperita* Linn.) at Kulu.

Material : INDIA : HIMACHAL PRADESH : Kulu: 2 ♂♂, from pepper-mint, 16. v. 1975, A. S. Sohi.

4. Helionidia karachiensis Ahmed & Khokhar

Helionidia karachiensis was reported from gold-mohar (*Delonix regia* (Bojer) Ref. at Karachi (Pakistan) by Ahmed & Khokhar (1971). This species was collected from the same host at Ludhiana (Punjab).

Material : INDIA : PUNJAB: Ludhiana dt. 20 ♂♂ and 25 ♀♀, from goldmohar, Ludhiana, 16. x. 1974, A. S. Sohi.

5. Typhlocyba longicephala Ahmed

Ahmed (1970 b) recorded *Typhlocyba longicephala* from cluster fig (*Ficus glomerata*

Roxb.) and forest-flame (*Butea monosperma* (Lamk.) Taubert from Pakistan. This species has since been found breeding on cluster-fig at Ludhiana (Punjab).

Material : INDIA: PUNJAB : Ludhiana dt., 16 ♂♂ and 18 ♀♀, from cluster-fig. Ludhiana 17. i. 1972, A. S. Sohi.

6. Zyginidia pakistanica (Ahmed)

Zygina pakistanica was reported by Ahmed (1969 a) from Rawalpindi (Pakistan) on *Ziziphus jujuba* Mill. This species has since been transferred to the genus *Zyginidia* Haupt as it possesses paired aedeagal atrial processes (Sohi, 1975). It was collected from the same plant species at Ludhiana (Punjab).

Material : INDIA : PUNJAB : Ludhiana dt. 30 ♂♂ and 26 ♀♀, from *Zizyphus mauritiana*, Ludhiana, 20. xii. 1974, A. S. Sohi.

Acknowledgements:—The author is grateful to Dr. O. S. Bindra (the then Dean of the Department of Entomology) and Dr. A. S. Sidhu Head of the Department of Entomology for the facilities provided. Thanks are also due to Dr. V. Prasad and Dr. V. C. Kapoor for going through the manuscript critically.

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A NEW SPECIES OF *CHRYSOPA* (NEUROPTERA : CHRYSOPIDAE) FROM INDIA

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(*Received 17 January 1977*)

Chrysopa (*Chrysoperla*) *sanandensis* **sp. nov. (Neuroptera: Chrysopidae) is described from Gujarat, India.**

The present note deals with the description of a new species of *Chrysopa* found in the collections of Chrysopidae received from Gujarat Survey. The type specimens will in due course be deposited in the collection of Zoological Survey of India, Calcutta.

Chrysopa (Chrysoperla) sanandensis sp.nov. (Figs. 1–7).

Holotype ♂ (pinned), genital structures on slide (No. 11/Guj). Tip of left antennae broken. Wings partially damaged.

Head: yellow; genae brownish, clypeus with brown borders; vertex greenish yellow palpi brown. Antennae : scape and pedicel yellow but the remaining portion of the flagellum pale brownish; setae on flagellum black.

Thorax : pronotum : shorter than broad, greenish yellow, a transverse ridge across the middle, short black hairs on the lateral margins. Mesonotum : greenish yellow, Metanotum : yellow but metascutellum whitish. Legs : pale yellow; tarsi brownish; claws dark brown and the hooks of the claws bent at right angle to the bases. Wings : (Figs. 1 & 2) membrane hyaline; absence of any spot; pterostigma yellowish, venation pale entirely; intramedian cell elongate its apex ends before the radio-medial crossvein. Number of gradates in forewings 6/7 and in hindwings 5/6; short black hairs on margins and veins.

Abdomen : whitish yellow with white pubescence. Sternite 8 + 9 elongated with rounded tip as shown in Fig. 3.

Gonarcus narrow with large side pieces; unpigmented, acute, distinct and smaller entoprocessus; long and straight arcessous; with a few gonosetae. Tignum rather stout, acumen with rounded apex in dorsal view.

Allotype ♀ (pinned : subgenital plate and spermatheca on slide No. 13/Guj). Antennae broken.

Colour as in the holotype ♂. Gradates in forewings 6/7 but in the hindwings 5/7.

Abdomen : discoloured. Subgenital not very stout, its distal lobe separated by a deep narrow incision. Spermatheca brown, vela short.

Paratype ♂♂ (pinned : genitalia on slide) : one of the specimens agrees well with the holotype ♂. Other specimen with the following variations : colour of the head and prothorax yellow; gradates of forewings 5/6; in hindwings 4/6 (right), 5/6 (left.).

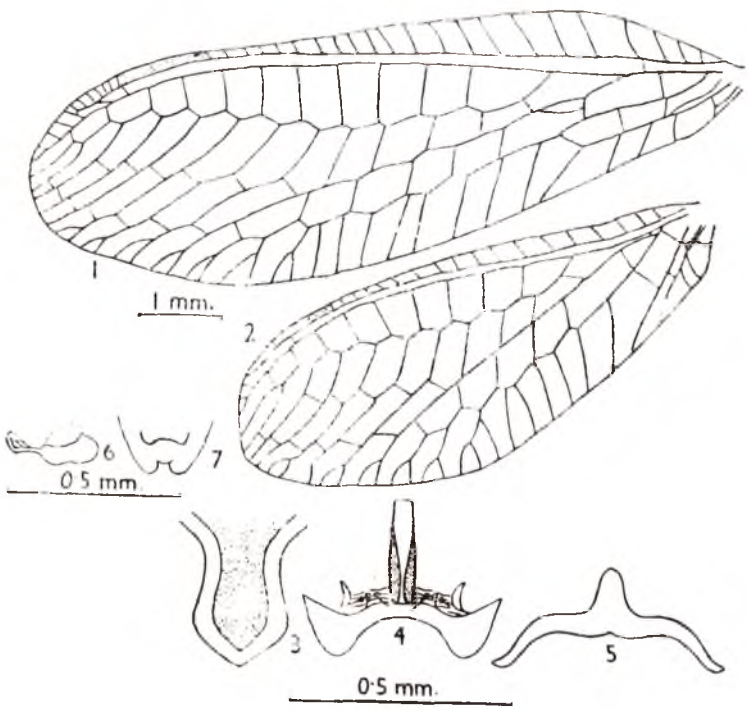

Fig. 1–7. *Chrysopa* (*Chrysoperla*) *sanandensis* sp. nov. 1. forewing; 2. hind wing; 3. Sternite 8 & 9 of male abdomen; 4. gonarcus with arcessus, dorsal; 5. tignum ventral; 6. spermatheca lateral; 7. subgenital plate, ventral view.

Paratype ♀ (pinned : tip of abdomen on slide) : colour same as in holotype. Gradates of forewings 5/6 (left), 4/6 (right); in hindwings 4/6 (left), 3/5 (right).

Material: **Holotype** ♂, INDIA : GUJARAT : Dadagram, Sanand, 8.xii.73, P.T. Cherian. **Allotype** ♀, INDIA : GUJARAT : Sabarmati, Ahmedabad dist., 7.xii.73, P. T. Cherian. **Paratype** ♂ ♀, INDIA : GUJARAT : Sanand, 3.xii.73, P. T. Cherian. **Paratype** ♂, INDIA : GUJARAT : Dadagram, Sanand, 8.xii.73, P. T. Cherian.

The species is closely related to *Chrysopa scelestes* Banks (Banks, 1911) but may be distinguished by the absence of any black cross vein, by the brownish cheek, by the same length of 2nd and 3rd cubital cell and by the structure of genitalia described and figured by Adams (Adams, 1959).

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ANDROTHRIPS FLAVIPES SCHMUTZ (INSECTA: THYSANOPTERA), A PREDATORY INQUILINE IN THRIPS GALLS

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***Androthrips flavipes* SCHMUTZ is being recorded for the first time as a predatory inquiline. Observations on the population periodicity, efficiency of predation and duration of the life cycle of *A. flavipes* are provided.**

Information on predatory thrips within galls appears comparatively meagre, the only species hitherto reported being *Mesandrothrips inquilinus* (PRIESNER) known to be predatory on *Liothrips kuwanai* (MOULTON) on *Piper* galls, *Gynaikothrips uzeli* ZIMM., on *Ficus* galls and *Mesothrips claripennis* MOULTON on *Bladhia* galls (TAKAHASHI, 1934; LEWIS, 1973) and *Liothrips brevitubus* KARNY from Taiwan (ANANTHAKRISHNAN, 1976). The biology and predatory behaviour of *A. flavipes*, an established inquiline in several thrips galls (ANANTHAKRISHNAN, 1969, 1973), is being reported for the first time. Observations presented here relate to the population periodicity, efficiency of predation, as well as the duration of life cycle of *A. flavipes* within galls of *Mimusops elengi*. The duration of various instars of the gall making species *viz.*, *Arrhenothrips ramakrishnae* HOOD ([1]*Mimusops elengi*), *Schedothrips orientalis* ANAN ([1]*Ventilago maderasapatana*), *Gynaikothrips flaviantennatus* MOULTON, ([1]*Casearia tomentosa*) and *Brachythrips dantahasta* RAMAK., ([1]*Memecylon edule*) with which *A. flavipes* is associated in the different galls, is also provided so as to indicate the comparative range of duration of the life cycles.

[1] Host plants.

Experimental rearing of *A. flavipes* within galled leaves in plastic rearing tubes (3.5/2 cm) without the eggs of the gall makers (*A. ramakrishnae*) and with their egg masses, clearly resulted in the mortality of the predator in the former case, while those provided with eggs survived and reproduced. The vials were covered with moist muslin and fresh eggs, larvae and pupae were offered to enable continuous feeding and sucked host materials were regularly removed so as to prevent fungal infestation. Rearing of gall making species stated above, were carried out in young fresh galls in petridishes covered with moist muslin.

Feeding preferences and life-cycle of Androthrips flavipes

From the viewpoint of feeding preferences, *Androthrips flavipes* were seen readily to prey upon first and second instar larvae and to a very limited extent on pupae and never on adults. Freshly killed adults were, however readily accepted and contents sucked through intersegmental membranes.

The eggs of *A. flavipes* are whitish, more or less elongate (L/W 347/112) and easily distinguished from the host eggs (Table 1). They are deposited by the pre-

TABLE 1. Comparison of life cycle of the predatory inquiline and gall making species (Average of 6 replicates).

Species	Egg L/W in μ	Pre ovi-period	Incu-bation period	I Larva	II Larva	pre pupa	I pupa	II pupa	Total duraton (days)
Predator									
Androthrips flavipes	347/ 112	4–6	4–6	3–4	2–3	1	2–3	1–2	13–16
Prey									
Arrhenothrips ramakrishnae	418/ 173	8–10	5–6	3–4	4–5	1	2–3	1–2	16–21
Schedothrips orientalis	388/ 173	6–8	5–8	1–3	4–5	1–2	1–2	2–4	14–21
Gynaikothrips flaviantennatus	425/ 196	5–6	7–9	4–5	4–5	1–2	1–2	2–4	19–27
Brachythrips dantahasta	386/ 144	7–10	6–8	3–4	3–4	1	3–4	3–4	19–25

TABLE 2. Nature of predation of *A. flavipes* on the eggs of the gall thrips species in the four different galls (Average of 10 galls).

	Host plant gall species			
	M. edule *B. dantahasta*	*M. elengi* *A. ramakrishnae*	*V. maderasapatana* *S. orientalis*	*C. tomentosa* *G. flaviantennatus*
Total No. of eggs	169	144	110	250
% of eggs predated	74	38	38	49[1]
% of eggs intact	26	62	62	51
No. of adult *A. flavipes*	29	4	22	1[2]
No. of larvae of *A. flavipes*	56	12	28	1[2]
No. of anthocorid	0	5	8	11

[1] Predation due to feeding of anthocorid bug *Montandoniola moraguesi.*

[2] Heavy predation of eggs even with meagre number of *A. flavipes* due to large number of anthocorid bugs which feed both on the predatory inquiline and its prey.

dator near the egg masses of its prey, and rarely in between. It is significant that the eggs of the predator hatch before those of the prey so as to provide easy access of food to the newly emerging predatory larvae. This is followed by a shorter life-cycle, an essential feature of an efficient predator. In view of the presence of *A. flavipes* within the galls of *Mimusops elengi, Ventilago maderasapatana, Casearia tomentosa* and *Memecylon edule,* a comparative idea of the duration of each of the gall making species is also included in Table 1.

Regarding the periodicity of the predator/prey species it may be remarked that the population of *A. flavipes* shows an increasing trend from October, reaching the maximum in the middle of February, a period when the gall maker *A. ramakrishnae* was under decline due to heavy predation. The population of *A. flavipes* in *Casearia tomentosa* and *Ventilago maderasapatana* was low in view of the high incidence of the predatory bug *Montandoniola moraguesi* (PUTON), which feeds both the gall maker as well as *A. flavipes.* The nature of predation of *A. flavipes* on the eggs of the gall thrips species in the four different galls is summarised in Table 2.

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FACTORS INFLUENCING FECUNDITY IN *TROGODERMA GRANARIUM*

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Starvation period of diapausing larvae affect the rate of pupation. Factors such as starvation, delay in mating *etc.* influence the fecundity of *Trogoderma granarium*.

Trogoderma granarium is a serious pest on stored grains and has a wide distribution. Mature larvae of this insect enter a facultative diapause. Diapausing larvae remain quiescent and emerge from their hideouts to feed (BURGES, 1963). They remain alive without access to food for very long period.

Adults of *T. granarium* are short lived and do not feed (HINTON, 1945). Mated females die within seven days after egg laying, while unmated ones live for 25 to 30 days. Males are short lived (7 to 12 days). Since the reproductive rate is an important parameter in determining the rate of increase in a pest population, it was thought that a study of the effect of various factors influencing the fecundity rate would yield useful information.

Insects were reared in controlled conditions on crushed wheat (KARNAVAR, 1967). Mature larvae, which failed to pupate within 45 days of emergence (at 30° C and 70% RH) were regarded as diapausing larvae. For starvation studies diapausing laravae of known age (three months in diapause) were separated from the culture and kept in clean glass containers. Exuviae were removed regularly. Diapausing larvae (3 months in diapause) were subjected to diapause breaking conditions (37°C and 70% RH) to obtain adults. Females were allowed to mate with newly emerged males. Mated pairs were left in wheat flour, the ovipoition medium and hatched larvae were counted.

Pupation of starved larvae

Diapausing larvae of *T. granarium* remain alive without food for very long period (KARNAVAR, 1973). During starvation, they moult and reduce in size and weight (from 5.7 mg to 2.4 mg after starvation for a period of 6 months, KARNAVAR & NAIR, 1968). Diapausing larvae were denied access to food for a period of 225 days and observed their moult pattern. The maximum number of moults registered by any larva was four. In a related species, *T. glabrum*, BECK (1971) has reported that starved larvae retrace the number of moults they have passed during starvation before they pupate. In *T. granarium* no such phenomenon could be noticed. When starved larvae (225 days of starvation) were refed at diapause breaking temperatue, 45% larvae pupated without moulting, 48.6% registered one moult and the rest moulted twice.

To ascertain whether feeding is essential for pupation, three batches of starved larvae were subjected to diapause breaking temperature. 70% of the larvae starved for 30 days pupated without feeding, while 40% pupated when starvation period was 90 days. None of the larvae pupated when starvation period was extended beyond 90

days. In such larvae feeding for 4–7 days was found essential for pupation.

Starvation and fecundity

Three batches of diapausing larvae were used to determine the effects of larval starvation on fecundity of the adults. Larvae were denied access to food for known period, at the end of which they were given fresh food and transferred to 37°C. Such larvae pupated within 7 days of introduction to food. Adults derived from larvae starved for 30 days and refed for 4 days produced 76.1 ± 15.4 eggs, while 75 days of starvation and 4–6 days of refeeding resulted in the production of 66.5 ± 17.8 eggs. When starvation was acute (390 days followed by feeding for 12 days) the derived adults could produce only 38.0 ± 8.2 eggs.

From the present study, it is evident that starved diapausing larvae pupate and reproduce within a short period when food is available. It is also clear that duration of starvation and not that of refeeding is the factor determining the fecundity rate.

Delay in mating on fecundity

Adults derived from diapausing larvae with access to food and mated within 48 hrs of emergence laid on an average 109 ± 19.4 eggs (KARNAVAR, 1972). When mating was delayed by 5 days the number of eggs produced was reduced to 85 (KARNAVAR, 1972). KARNAVAR (1972) has further reported that the number of eggs was reduced to 35 when mating was delayed upto 15 days and to 12 when the period was extended to 20 days. In the present study, the delay in mating was extended to 30 days (longevity of unmated females was found to be 25–30 days). Many adults mated on the 30th day of emergence, but no egg laying occurred. Examination of the ovaries of such adults showed almost complete resorption of the oocytes.

The capacity of diapausing larvae to pupate with brief period of feeding and to produce a fairly large number of eggs even after prolonged starvation of the larvae are commendable adaptations of this pest. Though delay in mating reduces the number of eggs, survival of the female for a month ensures the chances of mating with males of at least two generations.

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TWO SYMPOSIA ON INSECTS

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Entomologists in India had the unique opportunity this year to participate in two closely spaced symposia on Insect life. The first one was the *Symposium on Insects and Environment* held in the Dapartment of Zoology, University of Delhi from February 21–23 and the other was the *Second Oriental Entomology Symposium* held in the Entomology Research Unit of the Loyola College at Madras from March 23–27.

DR. M. S. SWAMINATHAN, Director General of I. C. A. R. and distinguished Agricultural Scientist, inaugurated both the symposia. Delivering the inaugural address he dwelt at length upon the efforts made in India by the various research Institutes under the ICAR to improve crop production, strategies evolved to minimise damage by pests and maximize production by improved agronomic practices and, when possible, on the sound ecological principle of recycling. He also highlighted the role played by entomologists in India in understanding the insect pests of crops and in formulating pest control programmes along modern lines. He did not forget in calling attention to the dangers posed by the newly emergent pests as an uneasy sequel to the development of high yielding cultivars and other cultural practices and stressed the need for conducting more research for containing the threat of these hexapods.

THE SYMPOSIUM ON INSECTS AND ENVIRONMENT was the first of its kind held at the National level and was organized by PROFESSOR K. N. SAXENA and his colleagues. About 90 papers were contributed to this symposium which were presented in three sessions. The session on "Distribution and abundance of insects in relation to environmental factors" discussed specific instances wherein abiotic and biotic factors determined the distribution, population size, community characteristics and the kinds of life cycles of insects leading an epigeic, edaphic or aquatic life. Agricultural pests and their parasites figured prominently in this session. Some of the papers discussed how the present day distribution provided evidence for past geological changes in land mass relations while a few others showed how species within a major taxon are limited in their distribution by altitude in the same geographic unit. Yet another study stressed the importance of microhabitats with suitable microclimatic conditions which enabled insects to survive the harsh environments that prevailed in the high altitude Himalayas. The session on "Physiological basis of insect-environment relationship" provided the much needed and possible physiological bases for a number of phenomena observed in the field studies. This session also discussed insect-host relationship, physiological mechanisms underlying resistance to pesticides, antifeedants in plants and environmental stimuli governing reproduction and behaviour. The session on "Insecticides and environmental pollution" was concerned with the degradation of pesticides in soil, their effect on microbial activity in soil, mutagenicity of pesticides,

translocation of pesticides and their accumulation in man and other animals and the effect of insecticides on beneficial insects. Apart from shedding light on the possible sources of danger of large scale usage of broad spectrum and long lasting insecticides this session provided some evidence which would allay the fear that the concentration of DDT has reached the limit of safety in man in some urban areas in India.

Though time did not permit the holding of a plenary session at the close of the symposium, one went with the impression that this well organised symposium largely succeeded in the difficult task of integrating various aspects of insect-environment relationships through the understanding that emerged out of fruitful discussions among the participants. PROF. SAXENA and his colleagues could achieve this by their thoughtful delineation of the areas of the symposium followed perhaps by a careful selection of the papers.

THE SECOND ORIENTAL ENTOMOLOGY SYMPOSIUM was organised by DR. T. N. ANANTHAKRISHNAN and his coworkers. Almost all aspects of study on insects have been covered by the symposium and the contributors were necessarily many. There were about 175 papers under six sessions. Largest number of papers (55) were presented under the session "Biotaxonomy, Ecology and Zoogeography". A little over half of the papers in this session were on ecology or on taxonomic and ecological themes and the remaining ones were on taxonomic and distributional aspects. If these papers were any indication of the nature of taxonomic research in India, it was gratifying to note that the interest of insect taxonomists was rarely confined to pure taxonomic problems. Most workers increasingly concerned themselves with ecology, biology and distributional aspects of the taxa which they studied from the systematic point of view. A refreshing part of this session was a set of contributions on energy flow, resource utilisation and resource limitation. The session on "Agricultural Entomology" discussed papers dealing with integrated control, pest damage to agricultural crops and forest trees, pest ecology and biological control. Papers dealing with control of agricultural pests with new insecticides, the effects of insecticides on natural enemies of pests, enzyme inhibition by insectides, insecticide residues etc., were considered under the session "Toxicology". A variety of physiological studies on insects were discussed under the session "Physiology" and they covered topics like digestion, nutrition, endocrine control of enzyme production, biochemical aspects of the nervous system, vitellogenesis, accessory glands in the reproductive system, effects of drugs on various physiological processes, bacterial symbiosis, behavioural physiology and ecophysiology. In the small session "Cytology and Cytogenetics" papers dealing with cytotaxonomy, chromosome morphology of natural populations, effect of drugs on chromosomes, parthenogenesis and genetic fine structure of specific chromosomal regions were presented. Studies on "Insects of medical and veterinary importance" formed the subject of yet another small session and the ten papers under it discussed the ecology and control of mosquitoes and the biology and ecology of fleas.

After the presentation of papers in each session the participants met to discuss in general the contributions made to the respective sessions and the points which prominently surfaced at the discussions were passed on to the plenary session. The plenary session took a number of decisions and a few proposals were made for passing on to research institutions in the country

and the Government of India. It was thought that in order to avoid confusion the nontaxonomists should be made aware of the recent revisionary studies on the common insects in India. This could be done by publishing short accounts of taxonomy, ecology and biology of the common species of insects in India which would enable the Indian worker to place his insect in the proper taxon. The Zoological Survey of India, it was felt, should take the lead in bringing out such publications in addition to the comprehensive fauna volumes. The participants were also of the opinion that there ought to be better co-ordination between workers in various branches of entomological studies and that this could be achieved to some extent by organising workshops. DR. SANTOKH SINGH of the School of Entomology, St. John's College, Agra and PROF. G. K. VEERESH of the Department of Entomology, Bangalore Agricultural University came forward to conduct workshops in Insect Taxonomy and Insect Ecology. Towards the close of the session the participants were anxious to know where they would meet next and when. The suggestion came spontaneously from DR. K. N. MEHROTRA, Head of the Division of Entomology, I. A. R. I., that the Third Oriental Entomology Symposium could be held in his department at Delhi some time in February, 1980 and the offer was accepted unanimously. At the conclusion of the plenary session, DR. D. N. RAYCHAUDHURI, permanent secretary of the Oriental Entomology Symposium, summing up the deliberations made special reference to the sincerity, enthusiasm and organisational skill of the Convenor of the Symposium, DR. T. N. ANANTHAKRISHNAN and the singular work turned out by his tireless young coworkers. Undoubtedly the Second Oriental Entomology Symposium fully realised its objectives.

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I, V. K. Kesava Prabhu, hereby declare that the particulars given above are true to the best of my knowledge and belief. ue

(Sd.)
Dr. V. K. Kesava Prabhu
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BOOK REVIEW

APHIDS OF ECONOMIC IMPORTANCE IN INDIA by A. K. GHOSH, The Agricultural Society of India, Calcutta, 1975, 134 pp. Rs. 30.00/$ 10.00

Aphids are well known pests of crops and form the largest group of insect vectors of plant diseases. As such, their complicated life cycles, polymorphic forms and generally polyphagous nature make their study often difficult and confusing. It is therefore commendable that an attempt has been made by the author, a serious student of Aphidology, to identify nearly 150 species of Indian aphids of economic importance, some of them serious pests and others having pest potential.

As a preliminary to the study, the author has very briefly indicated the economic importance, morphology and terminology used, along with methods of collection and preservation. Considerable effort has been made to provide a classification based on the economic importance of this group and the following areas are identified: aphid pests on cereals and grains, on vegetable crops, on fibre crops, on fruit trees, on spices, pulse crops, oil seeds, forest trees, tea and coffee, sugarcane, medicinal plants, and ornamental plants. Species coming under each of these heads have been tabulated with a list of host plants and distribution in India, followed by a deteailed key to the aphid species.

A very useful table on natural enemies of aphids and virus transmission of aphid pests, a brief discussion and a fairly exhaustive bibliography are also provided. The next edition would, I am certain, see the inclusion of better plates which should add considerably to this otherwise useful work to all students of Entomology.

The publishers deserve appreciation for the neat execution of the book.

T. N. ANANTHAKRISHNAN

NEWS

DR. T. N. ANANTHAKRISHNAN, Director, Entomology Research Unit, Loyola College, Madras, has been appointed Director, Zoological Survey of India.

PROFESSOR K. N. SAXENA, Head of the Department of Zoology, University of Delhi, shares the Hooker Award for 1974–1975 for his outstanding work in insect physiology.

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Books: NAYAR, K.K. (1973) *Elements in Insect Endocrinology*, Prentice Hall, India, 56pp. *Chapter in a book compiled and edited*: GILBERT, L. I. & D. S. KING (1973) Physiology of growth and development: Endocrine aspects, 249–370, *in: The Physiology of Insecta*, Vol. **1**, 2nd ed. (ed. ROCKSTEIN, M.), Academic Press, New York & London.

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